Presented by Canadian agencies and organizations currently undertaking aquaculture research in Canada

CANADIAN AQUACULTURE R&D REVIEW

Includes 200 summaries of recent research projects on salmon, trout, charr, oysters, mussels, marine species plus special full length features on completed projects across the country.

CANADIAN AQUACULTURE R&D REVIEW

Innovating in a Flattened World

Knowledge moving around the world nearly instantaneously is but one of the factors creating the new economy and society that Thomas Friedman describes as a "flat world: a global, web-enabled platform for multiple forms of sharing knowledge and work, irrespective of time, distance, geography and increasingly, language".*

The leveling of the global economic playing field that is at the heart of *The World is Flat* is a feature of today's aquaculture industry. One of the consequences is that it is now much more important than ever to rapidly capture opportunity from new knowledge generated by scientific research and technological development.

Yet Canada faces a challenge in mobilizing and commercializing such knowledge. The seventh annual innovation report of the Conference Board of Canada (2006) declares, "Research alone is not enough to secure Canada's success in global markets. It is essential to connect leading edge research to companies that can transform it into globally competitive products and services".**

This second edition of the *Canadian Aquaculture R&D Review* is helping to mobilize Canada's research knowledge and to connect knowledge producers - the investigators, technicians, and students – with knowledge needs and knowledge users in industry, communities and governments. It features almost 200 reports on research projects that are new or were active and ongoing since the spring of 2005.

The collection of reports for this publication was channeled through requests to funding agencies supporting aquaculture research and development in Canada. We are grateful for the efforts of all who contributed reports for this review and the efforts of Christie Whelan (DFO) in particular. Special thanks to Dr. Daphne Munroe who provided immensely valuable assistance in organizing and editing the contributions. And thanks to Peter Chettleburgh and the folks at Capamara Publications for putting it all together.

The R&D Review is the result of a collaboration between a number of parties including industry, federal and provincial governments and the research community. We wish to acknowledge the support of the British Columbia Aquaculture Research and Development Committee, Fisheries and Oceans Canada Aquaculture Collaborative Research and Development Program, AquaNet, the National Research Council of Canada Institute for Marine Biosciences, Canadian Centre for Fisheries Innovation and Reseau Aquaculture Quebec.

Tim DeJager, Ph.D.,
DeJager AquaLogic,
Project Coordinator

* Friedman, Thomas, 2005.
The World is Flat:
A Brief History of the 21st Century.
(New York: Farrar, Strauss and Giroux).
**Conference Board of Canada, 2006.
Lessons in Public-Private Research Collaboration: Improving Interactions Between Individuals
(7th Annual Innovation Report).

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Submitted materials may have been edited for length and writing style. Projects not included in this edition should submit material in time for the 2009 edition.

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Ontario study examines impact of net pens on wild stocks

More wild fish found around freshwater cage sites researchers find

If wild freshwater fish in Lake Huron are consuming fish feed and faeces from trout farms of the lake, they're doing so only in such miniscule quantities that it's not altering the ratios of the three most indicative stable isotopes in their bodies, according to a recent study in the area.

According to the lead scientific researcher on the project, Dr. Tom Johnston of the Ontario Ministry of Natural Resources, the results are good news for the lake's fish farmers: the project shows that their operations do attract increased numbers of fish from the wild, but they appear to do so for reasons apart from the sites being seen as a potential food source.

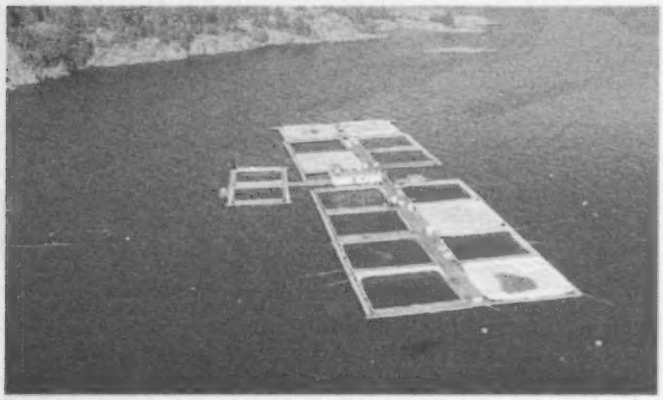
"Our study wasn't designed to demonstrate whether or not it (the pen site waste) is adversely affecting them, but it doesn't appear to be," said Johnston.

The study, which was funded through OMNR, the Department of Fisheries and Oceans and the University of Waterloo, detected no dietary shift in either the fish or in the zebra mussels, crayfish and larval may flies the field personnel also collected from the lake floor at the sites for analysis.

Johnston said the program looked at fish abundances and the stable isotopes in a selected number of fish at five different cage sites in the general vicinity of Manitoulin Island.

The field program followed a pilot study carried out in 2002. Using a DFO research boat field personnel set bottom grounded gillnets at farm sites and at reference locations about one-two kilometres away. The reference sites were chosen to closely match the fish habitat at each farm site for substrate and water depth.

The program looked at fish abundances and stable isotopes in a selected number of fish at five different cage sites in the general vicinity of Manitoulin Island.



Researchers discovered that wild fish like the pens for non-food reasons, perhaps for shelter against birds and other predators.

Some nets had smaller meshes, while others had larger meshes to catch only the larger fish, but care was taken to ensure consistency in which mesh size was used where and when.

The two sets of nets were left in place from about 7 p.m. until about 9 a.m. the next day, when they were retrieved and the fish counted, noted for species, measured for length and weight, and some had samples taken for laboratory analysis of their isotope ratios.

Based on this sampling design, Johnston said, the fish farms were shown to have no effect on the fish's isotope ratios, but it was noted that abundances of fish both large and small were greater around the pens than at the reference sites, especially spot-tail shiners, which only grow to about 75-100 mm long.

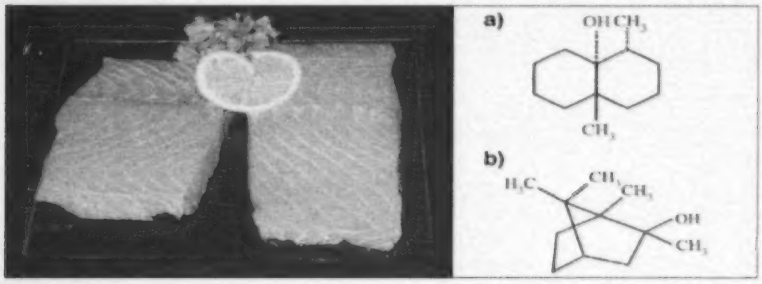
Apparently, said Johnston, the fish like the pens for non-food reasons, perhaps for shelter against birds and other predators.

"That was pretty consistent across all the sites," said Johnston. "I'd say the abundance was anywhere between about 50 and 100% higher at the pen sites, but you have to remember that fish abundances estimated from gillnet catches are highly variable.

Research team members: Tom Johnston, Michael Whittle, Michael Power. Submitted by DFO (ACRDP). For information contact: Tom Johnston (tjohnston@laurentian.ca).

– Quentin Dodd

Better tasting table fish produced in recirculated water



(Left) Fish fillets (Right) a) Geosmin b) MIB

Off-flavours in fish flesh are a problem for the aquaculture industry. They affect the quality of the final product. The problem of off-flavours has been observed in pond-raised fish and has now been encountered in fish raised in recirculating systems (RSs). The most frequently encountered off-flavour is described as "earthy/musty" and is caused by the accumulation of two compounds, geosmin and 2-methyl isoborneol (MIB), in fish flesh. These semi-volatile compounds are absorbed and stored in lipid-rich tissues. Cyanobacteria as well as actinomycetes are known to be sources of geosmin and MIB. A period of purging the fish in fresh water is necessary in order to get rid of off-flavours in the flesh; this period may last for several days and may be longer when the water temperature drops and the percentage of fat in the flesh increases.

The objectives of this project are to identify the microorganisms responsible for the off-flavours in RSs, develop strategies for optimizing the purging period and observe the effect on purging time of different diets with varying amounts of lipids.

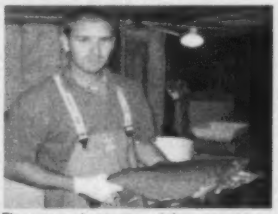
Research team: Houle S., Comeau Y., Kharoune M., Le François N., Proulx D., Bourque L., Desmeules A., Proulx E., Higgins S., Schrader K., Summerfelt S., Vandenberg G. For information contact Grant Vandenberg (Email: Grant.Vandenberg@sbm.ulaval.ca). Submitted by FQRNT.

May'05-Aug.'07

New Brunswick Arctic Charr brood stock development

Arctic charr *(Salvelinus alpinus)* is an excellent candidate for intensive culture, and it shows good growth performance in cold water. Canada, owing to its geographic location and climate, has significant potential for production of this species.

The long-term goal of the project is to develop a competitive Arctic charr culture industry in eastern Canada. The principal objective of this project is to continue to develop an Arctic charr brood stock with a known pedigree and good growth performance during culture and ability at maturity to produce juveniles adapted to local culture conditions. Adopting a selection protocol that guarantees the transfer of information from the industry to the program and in return optimize the transfer of genetic gains to the industry will attain this objective. Knowledge of the brood stock's pedigree will ensure the maintenance of genetic variability and the control of inbreeding. Whereas identification of the best performing families under real production conditions at the fish farmers' sites will make it possible to refine the selection protocol and develop high performance gene pools adapted to the industry.



The principal objective of this project is to develop an Arctic charr broodstock with a known pedigree, good growth performance and ability to produce juveniles adapted to local culture conditions.

The benefits of such a program will be realized once the industry has access to lines of Arctic charr offering superior zootechnical performance.

Research Team: Claude Pelletier and Annie Ferguson (Coastal Zone Research Institute), Christophe Herbinger (Dalhousie U.), Don Wolverton (NB Trout Farmers Ass'n), and the NB commercial Arctic charr growers. Submitted by DFO (ACRDP). For information contact Brian Glebe (E mail: GlebeB@mar.dfo-mpo.gc.ca).

Sept.'01-Mar.'06

Canola and flax replace fish meal and fish oil in rainbow trout diet

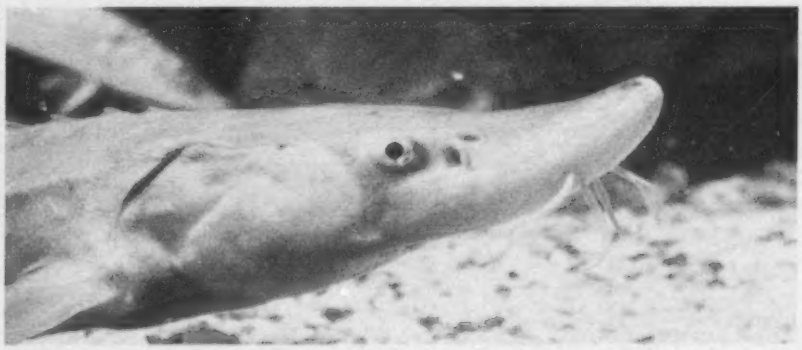
Canola and flax are two abundant Canadian crops that have desirable nutrient properties and a good potential to be used in fish feeds. Both pose numerous challenges, such as insoluble and soluble fibre that prevent immediate use. A newly developed canola protein concentrate (CPC) product with a high level of digestible protein and low levels of anti-nutritional factors is a promising alternative to fish meal. Flax is the richest plant source of omega 3 fatty acids and an excellent alternative to fish oil which is the currently used source of these essential nutrients.

The first objective of this research project is to determine the effect of long term feeding of CPC on rainbow trout (*Oncorhynchus mykiss*) growth rates, feed efficiency, intestinal histology and inflammatory responses. The second objective is to determine the effect of CPC and dehulled flax on flesh quality and reduction of the contamination of farmed fish by organochlorines. The research will measure the level of contamination of individual ingredients including fish meal oil presently used in Canadian aquafeeds. The ultimate goal is to reduce the dependence on wild fisheries for protein and oils in feed formulas, reduce contamination exposure and levels of organochlorines in farmed fish and develop a value added industry for abundant Canadian grain products and the commercialisation of canola protein concentrate.

Research Team: Murray Drew (U. Sask.), Andrew Van Kessel (Animal and Poultry Science), David Janz (Veterinary Medical Science). Report submitted by AquaNet. For information contact Murray Drew (Email: drew@sask.usask.ca). Submitted by AquaNet.

Apr.'04-May'06

Shortnose Sturgeon culture begins with growth and diet investigations



Sturgeon eggs (caviar) and meat are some of the most highly valued fish products in the world with demand continuing to grow. Yet the 27 species of sturgeon worldwide are almost all threatened or endangered. This project has conducted a series of experiments and explored models to accelerate the introduction of shortnose sturgeon for aquaculture in Atlantic Canada. This species can grow to 10 kg in 4-5 years with a minimum caviar yield worth at least $2,000 USD.

Diet development and husbandry techniques that promote high growth and maximize production are keys to developing this species for culture. The first objective has focused on development of a high growth diet. This involves several related areas of investigation. The analysis of body composition at various stages of development and eggs may provide an estimate of the qualitative nutrient requirement and the concentration of key nutrients retained by fish. Other feed related investigations include digestibility of potential feed ingredients, and protein and energy requirements. On the basis of this work, feed formulation experiments can begin.

Work on developing techniques and technology to promote rapid growth and maximize production has begun by investigating the growth rates of juvenile sturgeon grown at different temperature through ontogeny.

The information generated through this project will enable the industrial partner to develop economic production models and strategies for commercial sturgeon culture.

Research team: Matthew Litvak (UNB), Santosh Lall (NRC - Institute for Marine Biosciences), Larry Hammell (UPEI Atlantic Veterinary College), Suzie Currie (Mount Allison U), Saint Mary's First Nation. Project submitted by AquaNet. For information contact Matthew Litvak (E-mail: Litvak@unbsj.ca). Submitted by AquaNet.

Apr.'04-ongoing

Sex control in Arctic Charr

Early (pre-harvest) sexual maturation has been identified as a key constraint to commercial charr culture. The integration of all female diploid and triploid (sterile) charr into a commercial breeding program to reduce or eliminate early maturation of farmed charr is a potential solution.

One line of investigation is the production of triploid charr using pressure treatments identical to those already used in salmon and trout aquaculture. Early survival and growth rates, prior to the onset of maturity in diploids, have shown triploids to be inferior to diploids. However, the expected growth advantage of triploids will not likely be realized until diploids start to mature.

Another investigation involves the comparison of steroid (androgen) treatments for sex reversal via pre-feeding immersion or dietary administration. This has shown the optimum treatment for masculinization of charr is a feeding a diet containing 0.5mg/kg of the synthetic steroid 17 -methyldihydrotestosterone for 600 degree days beginning at first feeding. This yields close to a 100% male population. Some of these are genetic females which can be used as broodstock to create all female populations when crossed to normal females.

MSc candidate Marcia Chiasson collecting blood sample for ploidy analysis.

Sterile (triploid) Arctic charr.

Research team: Tillmann Benfey (UNB), Claude Pelletier (Coastal Zone Research Institute), Marcia Chiasson (UNB). Report submitted by Atlantic Canada Opportunities Agency - Atlantic Innovation Fund. For information contact Tillmann Benfey (E-mail: benfey@unb.ca).

Jan.'04-Dec.'06

Measuring sediment to water nutrient flux in lakes with fish farms

The development of freshwater aquaculture is currently limited in Canada by a perceived risk of eutrophication of the lakes in which farms may be located. There are gaps in the sound scientific knowledge regarding the effects of freshwater aquaculture on receiving waters. One of the gaps is the quantification of the nutrient fluxes from the sediments to the water column. Nutrients from fish cage farms usually increase the total nutrient content of the sediments. But such nutrient loading can also increase the concentration of soluble forms which can be released into the overlying water, becoming potentially available to primary producers.

Nutrient fluxes from sediments at two locations in lake 375 (Experimental Lakes Area, Ontario, Canada) are being quantified in order to estimate the overall contribution of the sediments affected by fish wastes to soluble P and N loading and the contribution of these fluxes to eutrophication. Each site has different sediment chemistry, with one site affected and one site unaffected by fish wastes. Major factors affecting the fluxes such as oxygen level and temperature are also being investigated. Using intact cores, the soluble reactive phosphorus, total dissolved phosphorus, total phosphorus, ammonia, nitrate and nitrite and total dissolved nitrogen fluxes are being measured under aerobic and anaerobic water conditions and at various temperatures.

Research team: Paula Azevedo (DFO), Cheryl Podemski (DFO), Gord Cole (Aqua-cage Fisheries Ltd), Mark Wagner (Martin Mills). Report submitted by DFO (ACRDP). For information Contact Paula Azevedo (E-mail: AzevedoP@dfo-mpo.gc.ca) Apr.'06-Mar.'07

Advancing the culture of walleye in ponds & recirculation systems

Culture techniques are now being developed for one of Canada's most economically valuable freshwater fish species, walleye (*Stizostedion vitreum*). The long-term strategy for walleye culture will involve land-based rearing in ponds and recirculation systems.

In order to identify the best wild walleye stock in Ontario for domestication, stock comparisons from Lake Erie, Lake Nipissing and Lake Ontario (Bay of Quinte) were compared. Lake Ontario walleye appear to grow best under culture conditions.

Determining the optimal conditions for the culture of this walleye stock in ponds and recirculation systems is the second objective. Experiments have been done to determine thresholds for oxygen, nitrite and ammonia that will affect the physiology and growth of walleye in closed systems. A moderate level of ammonia in water has been demonstrated to actually promote growth in juvenile walleye. Another series of experiments showed that the growth of walleye is not significantly influenced by changes in environmental salinity. Walleye-specific molecular tools have been developed to monitor growth and stress in very small individuals over short periods of time - which will significantly enhance further research on this species.

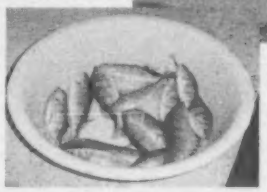
Improving broodstock maintenance and inducing spawning in captivity comprise the third objective. Together with the industrial partner, a domesticated broodstock has successfully been developed, as well as a feeding strategy to convert walleye fry to feed on artificial diet.

Research team: Bruce Tufts, Yuxiang Wang, Rashpal Dhillon, Barry Madison (all at Queens University). Project Submitted by DFO (ACRDP). For information contact: Bruce Tufts (tuftsb@biology.queensu.ca).

Apr.'02-Mar.'05

Diet formulations and fat content under investigation for yellow perch

Yellow perch has a strong market demand and remains one of Canada's most commercially valuable freshwater fish species. Supply is almost entirely based on Great Lakes fisheries with a small contribution from aquaculture production. Currently, limited information exists concerning the optimal diet formulation for yellow perch and no commercially available finfish formulation exists for this species. As a consequence, yellow perch aquaculture facilities must decide between formulations specific for salmonids, catfish, or tilapia.



The primary objective of this project is to determine the optimal diet formulation that will maximize perch fillet production under pond reared conditions while limiting the time required for fish to achieve market size (~150 g). This study is currently feeding yellow perch three commercial diet formulations consisting of 9%, 16%, and 23% fat contents. Results to date indicate that yellow perch attain fat contents similar to their diet treatments. But they attain substantially higher fat content than wild yellow perch. Much of this excess fat accumulates in large stores around the viscera. This may lead to greater losses of fillet production due to reproductive output. Thus, the second objective of this study is specifically testing if the higher fat salmonid feeds typically used for yellow perch aquaculture contribute to such excess fat accumulation. This effect is being tested by comparing growth, lipid content and gonad development on a monthly basis.

Research team: Gord Paterson, Ken Drouillard, Doug Haffner, and Aaron Fisk (all University of Windsor), Todd Leadley (Leadley Environmental Inc.), Doug Geiling (DFO). Report submitted by DFO (ACRDP). For information contact Gord Paterson (E-mail paterg@uwindsor.ca).

Mar.'05-Aug.'07

Tracking interactions between wild and farmed rainbow trout in Lake Huron

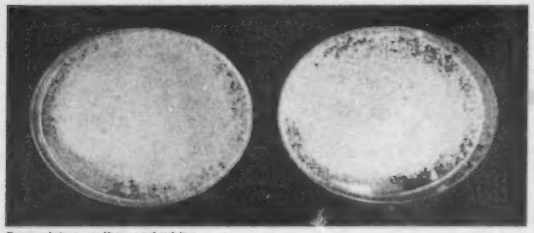
The potential genetic and ecological effects of cage culture escapes on naturalized and native fish populations are contentious issues. Although the debate has mainly involved marine operations, similar concerns exist for aquaculture in the Great Lake. To address some of these concerns, the Ontario Ministry of Natural Resources (OMNR) and the federal Department of Fisheries and Oceans (DFO) are investigating the ecological and genetic effects of aquaculture operations in Lake Huron on local wild rainbow trout populations.

The project involves the identification of geographic genetic structure among naturalized populations of rainbow trout in Lake Huron and Georgian Bay. The genetic signatures of source stocking and aquaculture populations are also being assessed. The project aims to quantify the range and extent of movement and gene flow among populations and measure the interactions between wild, stocked, and escaped fish. Genetic results from a pilot study in 2005 indicated that previous escape events had occurred but there was little evidence of interbreeding between the escapes and naturalized or domestic fish stocks. Genetic analyses of samples from source stocks and wild-caught rainbow trout collected in 2006 are continuing. This genetic work will be complemented by the addition of acoustic/radio telemetry investigations of rainbow trout movements.

Research team: Chris Wilson (OMNR), Tom Johnston, (OMNR), Doug Geiling (DFO). Report Submitted by DFO (ACRDP). For information contact Chris Wilson (e-mail: chris.wilson@mnr.gov.on.ca).

Apr.'05-ongoing

Using white corn gluten in feeds: a revolution in the world of colour



Corn gluten: yellow and white.

Corn gluten is increasingly being used as a protein supplement in feed formulations as a potential replacement for animal proteins. However, it has been established that oxycarotenoids (xanthophylls) in yellow corn gluten occasionally give the flesh of farmed fish a yellowish colour. This pigmentation problem restricts how much yellow gluten can be used in feeds. The primary objective of this study is to test the use of white corn gluten in experimental diets in order to avoid the problems associated with the undesirable yellow colouration of trout flesh. The second objective is supplementation of feed with lysine, an essential amino acid naturally found in corn gluten, in order to improve carotenoid binding in fish flesh via protein deposition.

The results of this study will enable researchers and aquaculturists to gain a better theoretical understanding of the pigmentation of trout flesh as a result of the effect of lysine, while promoting the use of white corn gluten as a low-polluting, non-colouring, high-energy protein source.

Research team: Dagenais G., Desmeules A., Proulx É., Higgins S. and the team of the Laboratoire régional des sciences aquatiques (LARSA), Bureau D., de Francesco M., Vandenberg G. For information contact Grant Vandenberg (Email: Grant.Vandenberg@san.ulaval.ca). Submitted by NSERC.

Sept.'05-Aug.'07

Treating fish farm effluents using a coagulation-flocculation process optimized with chitosan

Chitosan is a soluble polysaccharide that is derived from chitin, a molecule found in abundance in the shells of crustaceans. Marinard Biotech (a marine biotechnology company based in Rivière-au-Renard on the Gaspé Peninsula) is working to develop biomolecular applications for fisheries processing by-products, exploratory work carried out in 2001, realized that industrial-grade chitosan, when used in total replacement of polyacrylamide as a flocculating agent in the treatment of municipal wastewater, reduced the use of aluminum salts by two-thirds, while still meeting environmental standards for effluents.

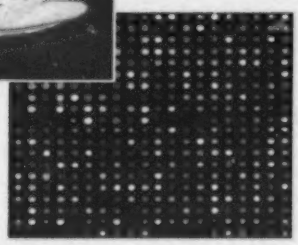
Research into removing phosphorus from the effluents of fish farms that use open (flow-through) systems and maintaining water quality in fish farms that use closed (recirculating) systems is currently focused on the use of conventional polymers (polyamines, acrylamides and polyacrylamides). The objective of this project was to verify the potential of using chitosan for the treatment of fish farm effluents in the Quebec context.

Compared with the other commonly used flocculants, chitosan has many advantages. First, less chitosan is needed to obtain the same flocculation effectiveness delivered by other chemical flocculants. Second, the flocculation effectiveness of chitosan is maximal at neutral pH values, while most chemical flocculants require acidic pH levels to precipitate. Finally, chitosan is a chelator of heavy metals, has virtually zero toxicity and is biodegradable.

Research team : Francis Dupuis (Marinard Aquaculture Ltée), Aquaculture Côte-Nord inc., Clermont Beaulieu (Marinard Biotech), Sébastien Sauvé (University of Montreal), Mourad Kharouna (École de technologie supérieure), Mélanie Michaud (Pisciculture Côte-Nord inc.), Éric Tamigneaux (Centre collégial de transfert de technologies des pêches). Report submitted by SORDAC. For information contact Clermont Beaulieu (Email: cbeaulieu@marinard.com)

Apr.'05-Sept.'06

Using DNA to determine the phosphorus requirements of rainbow trout



Rainbow trout and DNA microarrays.

Phosphorus (P) is a nutrient that is essential to fish growth. It is important to determine actual requirements in order to reduce P discharges, which are responsible for eutrophication of receiving water bodies. Nutritional requirements are usually estimated using empirical methods, relying on indicators whose sensitivity and accuracy may vary, such as growth, feed efficiency, serum P, urinary P and bone P, determined on the basis of feed trials with varying concentrations of the nutrient of interest. Various studies have already shown that the concentration of dietary P is the main regulator of expression of the genes involved in P metabolism in rainbow trout. There may be other P-responsive genes in rainbow trout that can be used to provide more sensitive, faster and more accurate methods of estimating minimum nutritional requirements.

This project aims to develop and use DNA microarrays to study the interaction between diets with varying P levels and P-responsive genes. This project will provide better knowledge about the dietary requirements of rainbow trout and enable us to formulate diets that are better adapted to their physiological needs, thereby minimizing P excretion in aquaculture effluents, an essential condition for the development of sustainable aquaculture in Canada.

Research team: Lall J., Proulx É., Kaffi C., Germain C., Robert C., Graval C., Vandenberg G. For information contact Grant W. Vandenberg (Email: Grant.Vandenberg@san.ulaval.ca). Submitted by NSERC.

Sept.'04-Jan.'07

Elucidating the genomic basis of hybrid vigor in brook trout

Quebec is the world's main producer of brook trout (*Salvelinus fontinalis*), a species native to eastern Canada. The objective of this project is to elucidate the physiological and genomic basis of hybrid vigour in brook trout. The approach used in this project integrates quantification of hybrid vigour for several traits of importance to aquaculture production, with a comparative analysis of gene expression profiles and research on endocrine regulators. This allows for the identification of the combinations of genetic lines and thermal regimes that make it possible to derive maximum advantage from the phenomenon of hybrid vigour in brook trout.

Elucidation of the genetic interactions underlying the expression of hybrid vigour will not only improve brook trout aquaculture, but will also enable the development of tools to more accurately predict the expression of this phenomenon in other cultured species and improve salmon farming and aquaculture production in general.

Research team: Louis Bernatchez (Université Laval), Céline Audet and Pierre Blier (Université du Québec à Rimouski), Daniel Cyr (Institut national de recherche scientifique – Institut Armand-Frappier). Project partners: Éric Caudrault (Aquaculture Forestville), Pierre East (Pisciculture de la Jacques Cartier inc.) Project submitted by SORDAC. For information contact Louis Bernatchez (Email : louis.bernatchez@bio.ulaval.ca).

Apr.'05-Apr.'08

A new low-phosphorus, high-energy feed for brook trout under investigation

The significant improvement in the quality of feeds, the increase in their energy content and the reduction in the feed conversion index have made possible a very significant reduction in solid waste and phosphorus and nitrogen discharges, and ultimately in feed costs for rainbow trout farmers. However, observations made by brook trout farmers suggest that brook trout (*Salvelinus fontinalis*) may have a more limited capacity than rainbow trout to use lipids as an energy source when fed high-energy feeds.

The objective of this study is to verify whether replacing lipids by proteins in brook trout feeds affects liver function, consequently reducing growth performance. Nine feeds (matrix of 3 lipid content levels X 3 protein content levels) will be formulated in collaboration with Skretting Canada. Laboratory studies and studies in commercial fish farms will be conducted in order to determine the effect of the feeds on growth performance, liver function (histological and physiological levels), body composition and nutrient discharges.

Research team : Éric Boucher (Interprovincial partnership), Yves Boulanger (Pisciculture des Alléghanys), Francis Dupuis (Marinard Aquaculture), Jean Maheu (Pisciculture Val-des-Bois), François Roberge (Pisciculture Mont-Tremblant), Grant W. Vandenberg (Laval University). Project submitted by SORDAC (Co-funded with ACRDP DFO). For information contact Éric Boucher (Email: Eric.Boucher@san.ulaval.ca).

Apr.'06-Apr.'07

Liming improves phosphate removal from fish farm sludge

Removing phosphorus from fish farm effluents is a central element of the sustainable development strategy for freshwater aquaculture in Quebec (STRADDAQ). Most of the phosphorus in culture water originates from uneaten food and fish feces, which are found mainly in particulate form.

Simple treatment processes such as the use of settling areas or rotary drum screens intercepts this particulate material, which forms a sludge of low dry-solid content (high dilution). The sludge must be extracted quickly in order to minimize solubilization of the particulate phosphorus. However, the significant volumes of sludge, combined with the capital costs of storage tanks and of transport for disposal, argue in favour of increasing the dry-solid content of the sludge in order to reduce its volume. Thickening by simple settling takes time and some of the particulate phosphorus solubilizes and is lost in the effluent.

The goal of this research project is to identify the design criteria needed to precipitate the phosphorus and prevent it from solubilizing through the addition of quick lime or slaked lime. Laboratory and field tests are being conducted with synthetic phosphorus solutions and fish farm sludge. The sludge used will be fresh (before solubilization) or collected from the supernatant of the sludge storage silo. The effect of the type of fish feed on phosphorus precipitation efficiency will also be tested. This project should indicate the best form and dose of lime to use, based on the characteristics of the sludge.

Research team: Yves Comeau, Francis Ardelean, and Denis Bouchard (École Polytechnique de Montréal), Robert Champagne and Dominic Marcotte (MAPAQ), Daniel Cagnon (Quebec Department of Sustainable Development, the Environment and Parks - MDDEP). Project submitted by SORDAC. For information contact Yves Comeau (Email: Yves.Comeau@polymtl.ca).

Apr.'05-Jun.'06

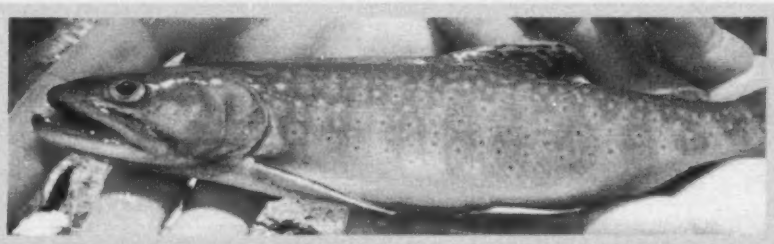
Optimizing waste treatment technology

The systems currently used by Quebec fish farms to treat particulate waste include membrane filters (drum filters), swirl separators and sedimenters. Some fish farmers have also installed new self-cleaning "Cornell-type" tanks. These tanks are equipped with a surface drain and a bottom drain in order to use a low proportion of the water flow to quickly remove fish farm particulate waste through the bottom drain. Concentrating the waste in this way increases the efficiency of the recovery equipment. This rapid recovery of fish farm waste makes it possible to recover a substantial proportion (approximately 70%) of the phosphorus which is also present in solid form. However, because of the different configurations of Quebec fish culture stations, the efficiency of the treatment systems can vary and may be greater or less than the theoretical values.

Implementation of STRADDAQ (Strategy for the sustainable development of freshwater aquaculture in Quebec) requires efficient waste treatment to be in place in a greater number of fish culture operations. The objective of this project is to obtain data on the operation and performance of various treatment systems and culture tanks currently in use in Quebec. This data will help optimize current treatment systems, while providing guidance for the design of future systems for the treatment of fish farm waste.

Research team: Robert Champagne and Dominic Marcotte (MAPAQ), 7 fish farmers. Project submitted by SORDAC. For information contact Robert Champagne (Email: Robert.champagne@mapaq.gouv.qc.ca).

Apr.'06-Jun.'06



Genetic control advances the culture of brook charr

The genetic control of economically important traits in brook charr (*Salvelinus fontinalis*) has been significantly advanced through this project in a number of ways. First, a classic quantitative genetic approach was employed to estimate the heritability for growth-related traits and maturation and to estimate genetic correlations and predict changes. Second, the genetic and molecular basis for disease resistance and maturation was investigated. Thirdly, a genetic map was created with quantitative trait loci (QTL) for other genes affecting growth traits. Additional work is in progress related to genetic variance, candidate genes for disease resistance and the molecular basis for precocious maturation. In addition, novel molecular tools for the characterization of several candidate genes were generated, including two growth hormones, several molecular cross-membrane signalling proteins and two loci of the major histocompatibility complex.

This study generated publications in leading research journals such as Aquaculture and Evolution. Partner laboratories in the project have trained over 13 high quality personnel currently working in aquaculture-related areas. All members of the team are part of the Réseau Aquaculture Québec, which integrates work on endocrinology, molecular and quantitative genetics in charr (*Salvelinus* spp) and other species. The project was also funded by SODIM (Société de développement de l'industrie maricole Inc.) and SORDAC (Société de recherche et de développement en aquaculture continentale).

Research team: Louis Bernatchez (Université Laval), Céline Audet and Pierre Blier (Université du Québec à Rimouski), Pierre Belhumeur and Daniel Cyr (Université de Montréal). Project submitted by AquaNet. For information contact Louis Bernatchez: (Email: Louis.Bernatchez@bio.ulaval.ca).

Apr.'03-Feb.'06

More stable fish feces in water: *a plus for the environment*

Feces of brook trout fed with different feeds.

One of the strategies being studied to reduce the environmental impacts of fish farm effluents from land-based facilities (in freshwater primarily) is to quickly separate feces (solid matter) as soon as they are produced by the fish. This can prevent solubilization of the phosphorus and nitrogen contained in the feces, thereby minimizing the growth of algae cyanobacteria and eutrophication of receiving water bodies. Phosphorus is the main factor limiting algal growth in freshwater, and feces contain 60% to 80% of the total phosphorus excreted by fish, with the rest present in soluble form, hence the importance of keeping the phosphorus contained in feces captive.

This project has two objectives: first to develop a reliable and reproducible method of measuring feces stability, and second to test different feed additives in order to substantially increase the stability of feces in water.

Research team: Vandenberg G., Lamarche M.-C., Comeau C., Kharouna M., Lambert R., Le François N., Lessard P., Proulx D., Desmoulins A. For information contact Grant Vandenberg (Email: Grant.Vandenberg@san.ulaval.ca) Submitted by FQRNT.

Jul.'04 Jul.'07

Tougher cage systems the goal of East Coast research

Most people who have not seen or experienced it themselves really have little idea of just how brutal ocean conditions can be for fish farming on the East Coast of Canada, according to the general manager of a net pen construction, design and repair company in the region.

So GMG Fish Services Ltd., a subsidiary of Cooke Aquaculture, has an ongoing program to work with scientists and researchers to continually improve net pen cage-system designs for the salmon farming industry. The program is based out of the company's net-pen design and manufacturing facilities in St. George, New Brunswick.

GMG Fish Services GM Alan Cook has experience with fish-farming on both the Canadian West Coast and East Coast, and he says there is truly little comparison between what East Coast farmers have to contend with, and the much more sheltered conditions on the West Coast.

In particular, said Cook, many of the East Coast farm sites are exposed directly to the open Atlantic Ocean, so the "fetch" or distance over which wind and waves can build is considerable.

To counter that, GMG has been working with the Institute of Ocean Technology's Dr. Bruce Colbourne in Newfoundland to come up with ways for net pen mooring attachments to absorb more of the shock from waves and currents.

The research, which is supported by the Industrial Research Assistance Program of the National Research Council, is aimed specifically at coping with extreme conditions in a deep-sea farming setting.

Tests are continuing on aspects such as different mooring-grid depths, the effect of weight rings, and a modified bird-net stand to handle the heightened problems East Coast farmers have not just with cormorants but also with seals.

Cook said that one of the big problems for East Coast fish farmers is that waves that measure three to four metres from crest to trough are not an uncommon feature on the coast.

"Those are significant waves, and you can get them 10-metres high in the open ocean out here," he said, adding that currents of two knots and more are also a comparatively frequent occurrence. Heavy ice loads in winter also have to be taken into account.

So GMG has been working with the Institute to improve net-cage systems so they can handle that kind of marine assault, using a scale model of cage systems in the Institute's 100-by-30-metre wave-simulation tank.

"We're trying to adjust improvements to the mooring systems, to reduce the shock loading on the moorings from high waves and currents and find ways to control the motion of the bottom panel of the net," he said.

Cook, who recently made a presentation on pen design to a conference on off-shore fish-farming in New Hampshire, said that one way East Coast fish farmers try to control or reduce the motion of the bottom of the net is through using weight rings, but he thinks that few people have much experience with them.

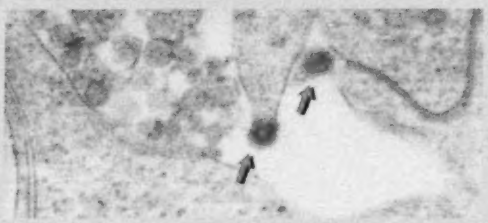
He also noted that there is a considerable difference between the submerged, research-sized open-ocean cage systems which have drawn so much attention off the United States, and the industrial-scale cages GMG makes – mostly, to this point, for internal use within Cooke Aquaculture.

"The design and the materials (for the submerged systems) won't allow them to be scaled up to the high-volume output size the industry wants and needs," he said. He said to scale them up to that – from roughly 6,000 to about 10,000 cubic metres – would hike the cost of the materials to about $30-35 a cubic metre, which would be prohibitive.

Submitted by the Institute of Ocean Technology

For more information contact Bruce Colbourne (Email: D.Colbourne@nrc-cnrc.gc.ca)

Exposing Atlantic cod to Nodavirus



Betanodavirus particles isolated from Atlantic cod, in cytoplasm of susceptible (E-11) cells.

Viruses of the family nodaviridae have been reported to cause the debilitating disease, termed either viral nervous necrosis (VNN) or viral encephalopathy and retinopathy (VER), in a wide variety of marine fish hosts throughout the world. The presence of betanodavirus in wild Atlantic Canadian cod adults was reported by Cusack and colleagues in 2002, with clinical disease recently confirmed in hatchery-reared cod juveniles from eastern Canada and USA. These clinical outbreaks have resulted in high levels of morbidity and mortality, supporting the hypothesis that betanodavirus poses a serious threat to the successful commercialization of Atlantic cod aquaculture in Canada.

The partial sequencing of a recently isolated NNV from striped bass in New Brunswick revealed variations and a distantly related virus in comparison to local isolates that were involved in previous outbreaks.

In this project, we injected juvenile cod with either a NNV isolated from haddock (known to cause disease in cod), or the striped bass isolate. Fish were sampled every month for one year and their tissues (spleen, kidney, eye, brain, blood) were tested for the presence of nodavirus by virology and RT-PCR. A new RT-PCR assay was designed to better match NNV sequences. Preliminary results show that the striped bass isolate did not kill cod, but fish remained positive for NNV more than a year after exposure.

Research team: Nellie Gagné (DFO), Anne-Margaret MacKinnon (DFO), Paul Harmon (DFO). Submitted by DFO (ACRDP).
For information contact Nellie Gagné
(Email: gagnena@dfo-mpo.gc.ca). Apr.'05-Mar.'07

Improving diagnosis of Betanodavirus in Atlantic Cod

To support the developing Atlantic cod aquaculture industry in Canada we are developing rapid, cost-effective pathogen screening methods with known performance characteristics for pathogens of Atlantic cod. Rigorous assessments of how diagnostic tests perform in clinical samples are required to make appropriate decisions regarding pathogen detection and control. To this end an initial collaborative research program examining the pathobiology of Atlantic cod nodavirus was recently undertaken by researchers at DFO (Moncton), NRC (IMB Halifax), Aquatic Diagnostic Services (AVC – UPEI), the University of Waterloo and industrial partners as part of an AquaNet project. This work has lead to the development of new or modification of existing diagnostic methods for use on strains of nodavirus that have been found in Atlantic Canadian waters.

Our current research activities, funded through the DFO industry sponsored ACRDP, are focused on optimizing the application of these methods for the screening of different life history stages and tissues of Atlantic cod for nodavirus. Techniques developed during this program will be available for use by federal and provincial agencies and commercial diagnostic laboratories in Canada. Improved disease surveillance will reduce the potential for losses due to nodavirus disease and ultimately improve the competitiveness of Canadian Atlantic cod farming.

Betanodavirus in the brain of a cod

Research team: Nellie Gagne (DFO), David Groman (AVC), Tokinori Iwamoto (AVC), Carmencita Yason (AVC), Stewart Johnson (NRC-IMB), Daryl Whelan (DFO), Larry Hammell (CAHS – AVC), Jane Symonds (CGP). For information contact Nellie Gagne (Email: GagneNA@dfo-mpo.gc.ca).

Sept.'06-Mar.'08

Selective breeding for elite Atlantic cod

Aquaculture often relies on wild populations for broodstock, which is the situation with Atlantic cod farmed in Canada. Broodstock selection is essential in order to produce cod that perform well in captivity.

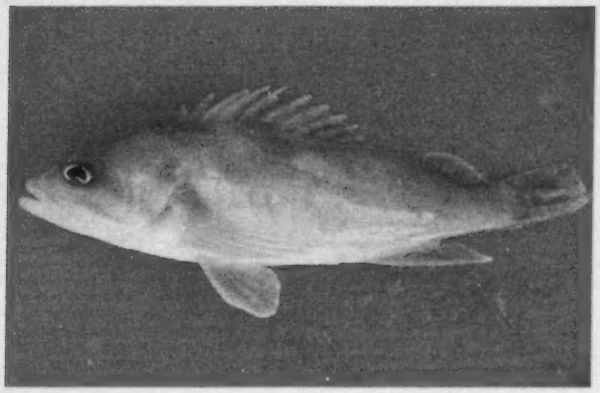
Until now, researchers in Atlantic Canada have used communal spawning to establish cod production runs. This approach has been used for haddock as well, and recent analyses of fish demonstrate a low genetic diversity of fish produced (primarily due to the dominance of individual males in group spawning situations). This project will implement established paired mating breeding protocols used in Norway to set-up cod families in Canada. Families will be reared separately until the 10-20 g phase, pit tagged, and stocked in sea cages. They will be grown to market size, and based on family performance elite broodstock will be selected for future use.

This study has six objectives:

- Development of broodstock reproduction and spawning protocols.
- Establish families and evaluation of early rearing performance.
- Examine effect of egg batch quality on family performance.
- Evaluation of sea cage performance and trait analysis.
- Conduct preliminary heritability estimates.
- Selection of elite broodstock.

Research team: Ed Trippel, Joe Brown, Steve Neil, Paul Harmon, Jake Elliot, Mike Szemerda, Frank Powell, Kjersti Fjalestad, Lynn Lush, Ian McMillan, George Nardi, Richard Rideout, Sharon Bowman, Jane Symonds. Submitted by DFO (ACDRP).
For information contact Edward Trippel
(Email: TrippelE@mar.dfo-mpo.gc.ca).

Jun.'05-Mar.'08



Developing the technology for culturing juvenile copper rockfish

The overall goal of this new project is to begin to develop the necessary technology to cost effectively culture copper rockfish (*Sebastes caurinus*) throughout their juvenile life history. Upon successful completion of the experimental work, considering both biological and economical perspectives, it is planned to locate the rockfish and to apply the acquired information at a land based culture facility that will be established by Ko-Un Fish Company Ltd., on the West coast of BC. Here, the copper rockfish will be grown to market size.

In the present study, we plan specifically to:

- Develop a premium quality cost effective formulated diet of optimal buoyancy for culturing juvenile copper rockfish. Known information about the nutrient and energy needs and acceptable dietary components of Korean rockfish will be used as a reference guide. Low capital cost pelleting equipment together with vacuum microwave drying technology will be employed.
- Establish the dietary protein and energy requirements of juvenile copper rockfish.
- Establish baseline health criteria for juvenile copper rockfish and then assess the health of this species during culture.

Research team: D.A. Higgs, T. Durance, S.K. Ballry, M. Rowshandeli, C-H. Huang, and P. Koniken. Submitted by DFO (ACRDP). For information contact D. Higgs (Email: higgsd@dfo-mpo.gc.ca).

Jul.'06-Apr.'07

Using photoperiod to manipulate growth and maturation of Atlantic cod

Impressive results and savings from a study assessing the effects of photoperiod on growth and maturation of Atlantic salmon in the Bay of Fundy, leads to the question of whether photoperiod manipulation on sea cages can be successfully applied to other finfish in Atlantic Canada.

In preliminary trials, early maturation in pre-market Atlantic cod affects ~100% of fish in sea cages. Thus, the maturity problem for cod is worse than for salmon. Repeated maturation of individual fish may occur before marketing as both males and females may achieve sexual maturity before attaining market size. Coincident with maturation and shedding of gametes in sea cages is a seasonal 25% weight loss in females and 12% in males. Appetite loss also occurs during spawning which leads to slower growth. During spawning and afterwards, fillets become 'jellied' (high water content) and are reduced in market value. This study will evaluate a method to decrease early maturation.

Other light problems also exist. Groundfish such as cod inhabit waters of 100 m depth (common range 30-300 m) where light intensity is very low. Species-specific differences exist in the production of "sunscreen", yet no investigation has been undertaken to examine levels of sunscreen in a gadoid species such as cod. The molecules necessary for synthesis of "sunscreen" are obtained directly from the diet, and thus fish fed on artificial diets may be more susceptible to UV radiation than wild fish. Use of shade cloth on sea pens may be necessary to inhibit stress due to UV radiation for groundfish such as cod.

The primary objectives of this project are:

- To adapt technology proven for species such as Atlantic salmon to Atlantic cod.
- To examine the degree of suppression of maturation in both sexes in pre-market and market fish.
- To examine the potential for somatic growth enhancement in light treatments.
- To examine "sunscreen" production and possible use of shade cloth in connection with 24 h lights.

Research team: Ed Trippel, Steve Neil, Chris Duffy, Paul Harmon, Andrew Davie, Jake Elliot, Mike Szemerda, Frederique Kandel, Frank Powell. Submitted by DFO (ACRDP). For information contact Ed Trippel (Email: TrippelE@mar.dfo-mpo.gc.ca).

Dec.'04-Mar'07

Evaluating grow-out performance of Atlantic halibut

Atlantic halibut, a white-fleshed fish with high market value and demand, is an excellent species to complement and diversify the Atlantic salmon aquaculture industry. Atlantic Canada's aquaculture industry is now poised to take advantage of investments made in developing local expertise and infrastructure in hatchery production of coldwater marine fish. However, given the economic uncertainties in rearing halibut, there is reluctance among farmers and lending institutions to risk the larger sums of money needed to purchase halibut juveniles compared to less expensive juvenile salmon. There is a need to complete pre-commercial trials and validate experimental data through a large pilot project.

Juvenile Atlantic halibut (50,000 individuals) of 3 size ranges were transferred into cages in December 2005 for a 3 year (2006-2009) performance evaluation and disease study. Research will focus on; 1) determining the optimum size for the transfer of juvenile halibut to sea cages for grow-out plus evaluate the consequences of early maturation and sex on growth performance, 2) fish health and vaccine trials using individually tagged fish to evaluate the efficacy and impact of vaccines on growth and survival, 3) production efficiencies and marketing aspects of this flatfish. Environmental monitoring will also be conducted.

Valuable economic, marketing and production data will be collected under commercial and scientific conditions. This is an ideal example of the collaborative commitment by multiple government and academic institutions working together to achieve scientific advancements for sustainable aquaculture development.

Tagging and weighing halibut.

Research team: Tillmann Benfey (UNB), D.J. Martin-Robichaud (DFO), Neil Ridler (UNB), Larry Hammell (AVC), Sandi McGeachy (NB DAFA), Skip Wolf (Canadian Halibut Inc.). Submitted by DFO (ACRDP). For information contact D.J. Martin-Robichaud (Email: martin-robichauddj@mar.dfo-mpo.gc.ca).

Jan.'06-Mar.'09

Cod stripping team: Lynn Lush (left), Andy Walsh (center) and Dwight Drover (back).

Cod broodstock development through selective breeding

To further develop Atlantic cod broodstock for the aquaculture industry, selective breeding of cod is being investigated in Atlantic Canada. To date, cod aquaculture has been based on broodstock derived from unselected wild-caught adult cod. The ability to identify and select parent fish which produce offspring exhibiting the most desirable characteristics will further advance the industry by producing the best quality fish possible.

Valued traits such as optimal growth, disease resistance, environmental tolerance, survival, and delayed maturation, if determined to be heritable, can be selected to produce an elite cod broodstock. Difficulties with traits such as these have been some of the limiting factors in the progression of the cod industry throughout Atlantic Canada. It is the aim of the project to help reduce these limitations by developing an elite broodstock.

The current ACRDP funded genetic selection broodstock project in Newfoundland and Labrador focuses on the development of optimal paired mating and egg collection protocols in Atlantic cod, and is working in conjunction with the recently announced Genome Atlantic, Cod Genome Project, funded by Genome Canada. The goal of these co-operating projects is the betterment of the local cod industry through the production of healthy, highly productive cod offspring and elite broodstock.

Research team: Lynn Lush (DFO), Jonathan Moir (Northern Cod Ventures), Velmurugu Puvanendran (Memorial U.). For information contact Lynn Lush (Email: lushlp@dfo-mpo.gc.ca). Submitted by ACRDP DFC.

Apr.'05-Mar.'09

Investigating Nodavirus in Atlantic cod and haddock

This project identified procedures and disinfectants that inactivate the Nodavirus in eggs and water, and examined viral survival in the environment, the vertical and horizontal transmission, and the ages at which cod and haddock are susceptible to infection. The researchers focused on the relationship between spawning stress and virus production in broodstock, and the relationship between stress, immune function and the development of the disease.

The researchers found that all of the nodaviruses were closely related to one another but were distinct from the European isolates already sequenced. Regardless of host species, isolates from close geographical localities were more similar than those from distant geographical areas. At the protein level, differences in coat protein sequences were seen only for strains isolated from Atlantic cod originating from Newfoundland.

These results suggested that NNV may have been present in Atlantic Canada and east coast of USA for some time and evolved to form a monophyletic group, distinct from other isolates found in cold water species. cDNA libraries have been produced and used to clone immune system specific genes important in host-viral interactions.

Research Team: Stewart Johnson (Dalhousie U.), Laura Brown (NRC-IMB); Brian Dixon (U. Waterloo); David Groman (UPEI), Carmencita Yason (AVC); Gilles Olivier (Dalhousie U.). For information contact Stewart Johnson (Email: stewart.johnson@nrc-cnrc.gc.ca).
Submitted by AquaNet. 2003-'06

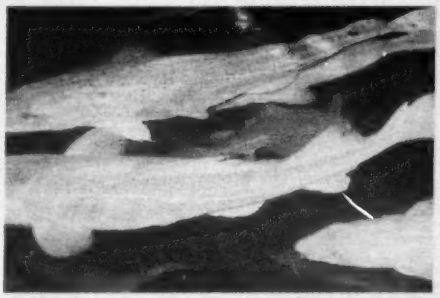
Newfoundland researchers test new diets for marine finfish in Atlantic Canada

The development of basic production protocols for Eastern Canada's marine finfish species— cod, haddock, wolffish, and winter flounder — is key for the modernization and diversification of the Canadian aquaculture industry. However, as with many new marine species, the rearing of the larval stages represents a major bottleneck for the mass production of juveniles. Problems related to nutrition of larvae are considered responsible for the majority of the mortality observed during larviculture. This research project focuses on the feeding of larvae and juveniles. Although hatchery feeding technology follows similar protocols worldwide, modifications are necessary to meet species-specific needs.

Research to date has identified better live-feed enrichments by improving lipid to protein and essential fatty acid ratios that promote best performance in cod and haddock larvae. The influence of dietary lipids on the stress response of cod larvae has also been investigated. Exposure to stress caused significant differences in larval survival between dietary treatments. Whole body corticosteroid concentrations are now being analysed. In addition, work is in progress to determine the thermal sensitivity of protein synthesis and degradation in juvenile spotted wolffish throughout their development. To do this a new method has been developed for measuring the rate of protein synthesis using mass spectrometry.

Research team: Joe Brown, Alexandre Garcia, Stewart Johnson, Simon Lamarre, Chris Parrish and Sarah Westelmajer. For information contact Chris Parrish (E mail: cparrish@mun.ca).
Submitted by AquaNet. Apr.'03-May'06

Haddock Broodstock, Sandy Cove Facility, NL.


Cod Broodstock, Aquaculture Research and Development Facility, MUN, NL.

Researchers optimize lipid utilization in marine finfish diets

Culturing alternate marine finfish species to Atlantic salmon on a commercial scale faces many challenges. While salmon have high muscle lipid deposition, sablefish and halibut have intermediate lipid deposition and cod and haddock have low muscle lipid content. As a result, dietary lipid requirements vary for these different species and need to be tailored accordingly. Signs of fatty acid deficiency include skin lesions, fin erosion, susceptibility to stress, fatty liver and embryonic deformities.

Our research project has generated new information on lipid utilization particularly in regard to essential fatty acid requirements, nutritional values of various lipid sources, and energy utilization for haddock, sablefish, cod and Atlantic halibut. Different experimental diet formulations were tested to examine the effects of partially replacing anchovy oil in grower diets for the preceding fish species with either cold pressed flaxseed oil, canola oil, and/or poultry fat with respect to fish growth, health and flesh quality responses. Also, attempts were made to ensure that the flesh lipids contained sufficient omega3 (n-3) highly unsaturated fatty acid levels at the "finishing stage" to maintain the human health benefits associated with these important fatty acids.

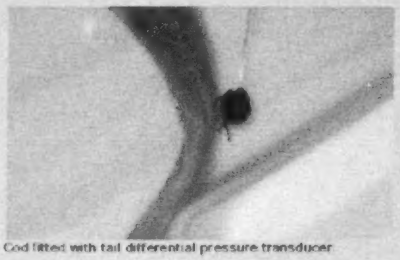
We also studied the impacts of the different dietary lipid compositions on the basic immune systems of these fish species and made recommendations on the possible implications for fish health management. The research showed that flaxseed and sunflower oil-rich diets caused an increase in the monounsaturated fatty acid content of muscle and other tissues and in some species resulted in fatty liver and related symptoms. Diets containing the alternate lipid sources therefore need be complemented by marine fish oils to increase the polyunsaturated fatty acid content of the fish before they can be marketed and to ensure adequate dietary concentrations of n-3 highly unsaturated fatty acids and arachidonic acid for good growth, health and normal tissue structure.

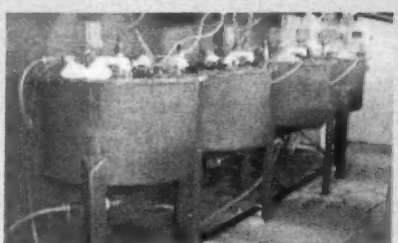
Research team: Santosh Lall, Dave Higgs, Fereidoon Shahidi, Shannon Balfry, Carla Walbourne, Dulce Alves Martins, Erin Friesen, Duan Zeng, Ying Zhen. For more information contact Santosh Lall (Email: santosh.lall@nrc-cnrc.gc.ca).
Submitted by AquaNet. Sept.'03-'06

Immune function, stress and metabolism of haddock and Atlantic cod

The aim of this research was to enhance growth and reduce disease-related losses at cage sites by: optimizing feeding protocols and diet composition at the cage sites when water temperatures are sub-optimal; understanding how water temperature and aquaculture practices influences stress, metabolism, and immune parameters; and testing the effectiveness of stimulants of the immune system at improving growth and reducing disease occurrence.

Researchers involved in this study conducting feeding (diet), stress and growth trials on cod and haddock at different temperatures, and swim-performance tests on cod to evaluate technologies with potential use in telemetry systems for monitoring metabolism and activity. They also completed DNA sequencing of primary immunological molecules from haddock and cod, tested the effectiveness of several immunostimulant products, and developed and refined effective immunostimulant protocols. The research has identified several immunostimulant products and developed application protocols that appear to be effective in stimulating the immune system and reducing infection rates when exposed to some pathogens (e.g. Loma). It has led to a much better understanding of the stress responses of haddock and cod in relation to husbandry and environmental conditions, and determined that both EMG and ultrasonic tail differential pressure transducers have potential for use in telemetry studies on activity/metabolism in free swimming gadids.


Cod fitted with tail differential pressure transducer.


Computer controlled, and automated, tank respirometry system used to measure the cost of digestion in groups of juvenile Atlantic cod and haddock.

Research team: Kurt Gamperl, Joe Brown, Duane Barker, Brian Dixon, Stewart Johnson, George Iwama, Scott McKinley, Atef Mansour. For information contact Kurt Gamperl (Email: kgamperl@mun.ca).
Submitted by AquaNet May'03-Sept.'06

Spotted wolffish cultivation: a pilot scale study

Technician Danny Ouellet holds a wolffish.

Private investors and researchers in Canada and Norway have been investigating the potential for spotted wolffish (*Anarhichas minor*) aquaculture. This project facilitates the collaboration of Canadian and Norwegian researchers with the industry partners in order to address the development of a joint broodstock and nutrition program.

The objectives of this project are to acquire, maintain and manage brood stock populations for future support of R&D and commercial initiatives by increasing juvenile production levels, produce reliable growth and productivity data for North American populations of spotted wolffish, provide economic analyses of spotted wolffish cultivation, and plan pilot scale production operations. The broodstock genetics program includes spotted wolffish acquisition and performance for comparison of Canadian and Norwegian stocks. Juvenile and grow-out trials to commercial size will assess the growth performance of Canadian stocks (versus Norwegian) in relation to temperature and salinity environmental conditions.

Bio-economical research aimed at spotted wolffish cultivation will contribute towards building a knowledge base and likely validate further investments in this commercial activity both by governmental agencies and industrial partners. Price considerations, costs of production and solving important input constraints are important aspects for a successful commercialisation. The project will contribute to "best practice" technologies not only for the production of juveniles, but also for the production of the finished product and help establishing realistic estimates of cost by a commercial enterprise.

Research team: James Wilson, Nathalie Le François, Pierre Blier, France Dutreuil, Robert Roy, Laura Halfyard. For information contact James_wilson@uqar.qc.ca). "Submitted by AquaNet. Nov.'04-Mar.'07

Flatfish genomics and disease research

Disease caused by viral and bacterial infections limits the production of juvenile marine finfish in many regions including Canada and Spain. Atypical *Aeromonas salmonicida* and nodavirus infections are cause for concern among the marine finfish aquaculture industries in both of our countries. Within this collaborative project we have developed genomic resources for Atlantic halibut and turbot including expressed sequence tags (ESTs) and cDNA microarrays. These resources have been used to examine their responses to vaccination (halibut) and disease challenge (halibut and turbot). In addition to providing tools for flatfish research this program has allowed for exchanges of graduate students and researchers between the partner institutions and provided opportunities for advance training in the application of molecular biology in fish disease research.

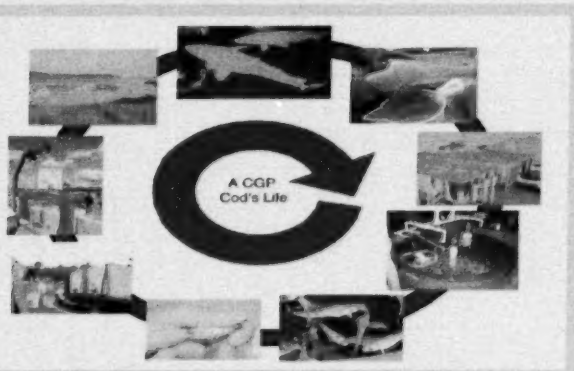
Research team: Stewart Johnson (IMB NRC), Antonio Figueras (CSIS), Kyoung Park (NRC-IMB), Laura Brown (NRC-IMB), Beatriz Novoa (IIM CSIC), José Meseguer Peñalver (Campus de Espinardo), Victoriano Mulero Méndez (Campus de Espinardo). Submitted by NRC-IMB. For information contact Stewart Johnson (Email: stewart.johnson@nrc-cnrc.gc.ca).

Sept.'04-Mar.'07

Modeling offshore cage systems for best performance

In 2004, IOT researcher Bruce Colbourne completed a series of model tests of a new surface cage/mooring/feeding system developed by AEG Ltd of New Brunswick. This work was supported by the Industrial Research Assistance Program of NRC. Based on a successful set of experiments, AEG has embarked on a series of full scale prototype evaluation trials. The feeder component of the system was deployed in early 2006 on an existing farm in NB and preparations are underway to conduct full scale trials of the cage and mooring system, in early 2007. The results of the full scale trials will provide AEG with in-situ performance data and will be used by IOT researchers to further develop modelling and scaling techniques.

Research team: Bruce Colbourne. Submitted by NRC. For information contact Bruce Colbourne (Email: D.Colbourne@nrc-cnrc.gc.ca).



Atlantic cod genomics and broodstock development the focus of East Coast research

The decline in wild cod populations has resulted in fisheries closures throughout Atlantic Canada. Cod aquaculture is recognized as a way to supply cod to the marketplace while providing stability to the established salmon aquaculture industry through species diversification. Broodstock selection is an important aspect of developing a new candidate species for culture. The Atlantic Cod Genomics and Broodstock Development Project (CGP, www.codgene.ca), an $18.1 million project managed by Genome Atlantic, was initiated to create two regional family-based selective breeding programs in New Brunswick/New Hampshire and Newfoundland & Labrador and to develop fundamental cod genomics tools for application within these programs. Cod families will be evaluated and selected for commercially valuable traits such as growth, survival, age of sexual maturation, stress tolerance, disease resistance and product quality and yield.

To date the CGP has produced 107 full and half sibling families for communal rearing in sea cages. Preliminary data analysis has revealed significant variation among families for traits such as juvenile growth. The project has also more than doubled the amount of cod DNA sequence data available in the public domain (3,500 sequences). These sequences will be analyzed to help identify DNA markers associated with traits, such as disease resistance and stress tolerance. The CGP also includes social research in intellectual property protection, environmental law, and public consultation.

Research team: Jane Symonds (Huntsman MSC), Sharen Bowman (Atlantic Genome Centre), Keith Culver (UNB), Jake Elliott (Cooke Aquaculture Inc), Kurt Gamperl (OSC MUN), Stewart Johnson (NRC-IMB), Jonathan Moir (Northern Cod Ventures Ltd.), George Nardi (GreatBay Aquaculture), Andy Robinson (U. Guelph), Ed Trippel (DFO). For information contact Jane Symonds (Email: jsymonds@huntsmanmarine.ca). Website: www.codgene.ca. Submitted by Cod Genome Project.

Jan.'06-Dec.'09

Researchers test alternate protein sources for marine finfish

The need for nutritionally balanced, cost-effective diets for development of Atlantic halibut, cod and haddock culture in Atlantic Canada is widely recognized. Our present research at NRC's Institute for Marine Biosciences addresses key areas of protein utilization and metabolism by marine fish. Proteins and their constituent amino acids are essential components of aquatic animal diets. Dietary protein requirements of these fish for maximum growth ranges from 45-55 % protein provided sufficient and appropriate amounts of essential amino acids and available energy are supplied.

Although high-quality fish meal is the major source of protein in marine fish feeds, the increasing demands of global aquaculture upon this finite resource necessitates that feeds become increasingly comprised of alternative protein sources of plant and/or animal origin. Incorporation of highly digestible alternative protein sources in marine fish diets must support similar performance to fish meal, make economic sense and, concurrently, have little effect upon fish health and the environment. Measuring nutrient and energy digestibility is a crucial first step in determining the potential use of alternative protein sources in least-cost ration formulations.

We have conducted studies with halibut, haddock and cod to determine the protein and energy digestibility for a range of feed ingredients widely available in Canada, including fish meals, crustacean by-product meals, animal by-product meals and plant-based feed ingredients (including oilseeds, pulses and cereal grains). The projects have demonstrated that marine species digest nutrients and energy from alternate protein sources relatively well and there is good potential to increase the use of these resources in marine fish diets, especially, meals of crustacean, oilseed and/or cereal grain origin.

Research team: Santosh Lall, Sean Tibbetts, Joyce Milley and Randy Peach. For more information contact Santosh Lall. Submitted by NRC IMB. (Email: santosh.lall@nrc-cnrc.gc.ca)

Apr.'04-Dec.'06

Halibut Genomics:
An array of opportunities

Atlantic halibut is a promising species for the aquaculture industry in Atlantic Canada. However, significant gains in production can be made by improving our knowledge of the basic biology of this animal and by selective breeding of individuals with desirable traits. This is the focus of the $5.1M Pleurogene project (www.pleurogene.ca) at the National Research Council's Institute for Marine Biosciences (NRC IMB). Funded by Genome Canada/Atlantic and Genome Espana, the project aims to enhance flatfish aquaculture using large-scale genomics and proteomics.

Two evolutionarily related, aquaculturally-relevant fish species are under investigation as part of Pleurogene: the cold-water Atlantic halibut and the Mediterranean Senegal sole. Building on the significant efforts in halibut mapping by researchers at DFO St. Andrews, NRC IMB and Scotian Halibut Ltd., genetic linkage maps are being constructed for both species, and will be used in the selection of improved brood stock. In addition, large scale sequencing efforts have resulted in the acquisition of approximately 13,000 new halibut and 10,000 new sole sequences, a phenomenal increase in what was previously known. This sequence information has been incorporated into two microarray platforms that will be used to simultaneously monitor changes in the expression of thousands of genes in response to changes in diet, disease, environmental change, stress or any other parameter of interest to producers of fish in intensive culture conditions. Improved understanding of the biological processes underlying fish growth and development will ultimately lead to enhanced production and economic gain.

Top: Female halibut being stripped of eggs.
Above left: Adult halibut in tanks.
Above right: Subgrid of halibut microarray.

Research team: Sue Douglas, Michael Reith, Harry Murray, Makoto Matsuoka, Leah Knickle, Darrin Reid, Cheryl Smith and Jennifer Kimball. Submitted by NRC IMB.
For more information contact Sue Douglas.
(Email: susan.douglas@nrc.ca)
Website: www.pleurogene.ca

Aug.'04-Jun.'07

Comparison of stress responses in finfish

Despite a large number of studies, we still have a poor understanding of how stress affects fish health, reproduction and growth. Furthermore, it is not known whether all species of fish will respond to stress in the same manner. Our research is focused on understanding the effects of stress on physiological and immunological processes of fish.

We are comparing the effects of short (heat shock or handling) and long-term stress (daily handling) on species of interest to the aquaculture industry such as Atlantic salmon, cod and haddock. We have found that there are differences in the stress response between species. Long-term stress suppressed growth in haddock but not in Atlantic salmon. Comparison of the stress hormone levels (cortisol) has shown that Atlantic salmon adapts to daily handling while haddock do not. Cod and haddock, unlike Atlantic salmon did not show increased plasma glucose levels when subjected to different stressors. Cod and haddock also did not increase heat shock protein 70 (hsp70) levels in response to a heat shock.

The relationship between these results and the immune response is being investigated. These studies are showing that species react differently when subjected to the same stressors; demonstrating that husbandry practices in aquaculture operations might have to be fine-tuned to take into consideration the species being raised.

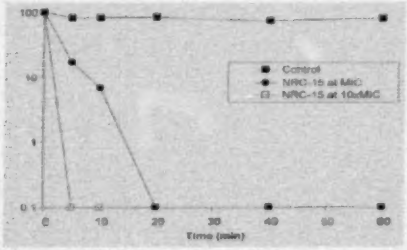
Research team: Luis Afonso, Stewart Johnson, Laura Brown (NRC – IMB) and Kurt Gamperl (OSC MUN). Submitted by NRC-IMB. For information contact Luis Afonso (Email: luis.afonso@nrc-cnrc.gc.ca).

Apr.'04-Mar.'08

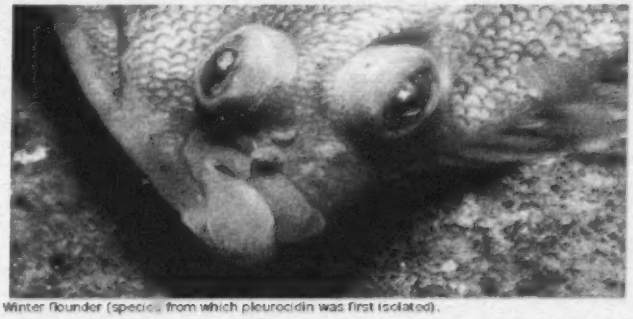
Flatfish antibiotics: novel therapeutants from unlikely sources

Fish from Atlantic Canada are not just a delicacy served on a plate – they can also be an important source of novel therapeutants, and in fact coldwater flatfish may prove to be just that. Researchers at NRC's Institute for Marine Biosciences have used genomics to isolate antimicrobial peptide coding sequences from marine fish with the aim of producing effective low-cost alternatives to increasingly resistance-prone antibiotics.

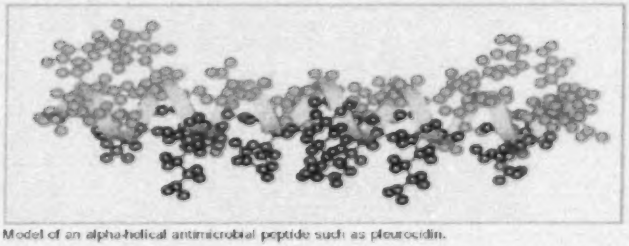
First isolated from the disease resistant winter flounder, these molecules have since been isolated from a wide variety of related flatfish. Synthetic peptides based on the gene sequences have been tested against a diverse spectrum of bacteria as well as a fungus and some have shown potent antimicrobial activity, whereas toxicity against fish and human cells is negligible. In addition to their crucial role in killing microbes, these peptides may play a role in host defence by mobilizing the immune system to ward off infections, heal wounds and even prevent tumor growth. Current research is directed towards the application of these molecules in aquaculture, where they may be of use in treating disease outbreaks in larval fish that are not amenable to vaccination. In addition, preliminary studies are underway to test their potential in human medicine.



Killing curve of Multiple Resistance Staphylococcus Aureus (MRSA) by pleurocidin NRC-16.



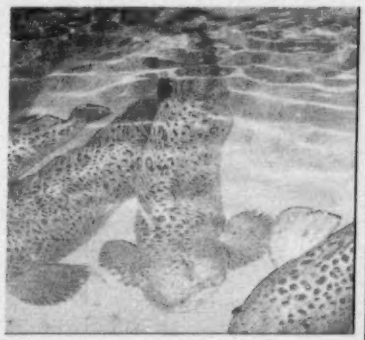
Winter flounder (species from which pleurocidin was first isolated).



Model of an alpha-helical antimicrobial peptide such as pleurocidin.

Research team: Sue Douglas, Aleks Patrzykat, Jeff Gallant, Harry Murray, Bandi Srinivasulu, Anna Greenshields and Leah Knickle. Submitted by NRC IMB.
For more information contact Sue Douglas. (Email: susan.douglas@nrc.ca)
Website: http://www.imb.nrc.ca/projects/peptides/index_e.php

Shortening the reproductive cycle of the wolffish using photoperiod



A number of studies have shown that manipulating the photoperiod shortens the reproductive cycle in fish and can increase the production of juveniles. One constraint on the development of the wolffish mariculture industry is the lack of a large number of eggs and juveniles. The main objective of this study is to reduce the maturation and spawning cycle of a wolffish population by manipulating the photoperiod. The accelerated maturation is monitored by measuring steroids (estradiol, 11-ketotestosterone) in the plasma of males and females. We will also develop an immunoassay for measuring the egg protein vitellogenin (VTG), a tool for monitoring female gonad development.

The experiments began in January 2006 at the Centre aquacole marin de Grand Riviere. The manipulation study began with the Atlantic wolffish (*Anarhichas lupus*) in order to test the method with a sufficient number of spawners. One group is being exposed to a seasonal photoperiod, while the second is being exposed to a shortened seasonal photoperiod of eight months. The experimental tanks have been isolated using photoperiod control tents, equipped with a dawn and dusk simulator. Every month, blood samples are taken and the spawners are examined by ultrasound.

Preliminary observations indicate an impact of the photoperiod on the regulation of the reproductive cycle. The morphometric measurements of growth indicate that the oocytes of the experimental groups are more developed than those of the control groups. At the Maurice Lamontagne Institute laboratory, we are continuing work on development of an ELISA for VTG (protein characterization, antibody validation).

Research team: Robert Roy, Nathalie Le François, Bernard Antonin Dupont Cyr, Domynick Maltais, Robert Vaillancourt. For information contact Robert Roy (Email: royro@dfo-mpo.gc.ca). Submitted by SODIM.

Jun.'05-Mar.'08.

East Coast project measures net drag & added mass

Institute for Ocean Technology (IOT) researchers Bruce Colbourne, Wayne Raman-Nair, Pengfei Liu and Shin Chin, with support from AEG Ltd of New Brunswick and the Canadian Centre for Fisheries Innovation (CCFI), continue working on a project to quantify the added mass and drag characteristics of full scale and small scale netting.

This year a Memorial University of Newfoundland Graduate student, Cheslav Balash, completed a number of experiments with a new drag measuring apparatus built at IOT. This has allowed the group to more accurately quantify the steady state drag for various types of netting. A first round of experiments has been conducted in waves and techniques to extract the added mass coefficients from this data are being developed. In addition a numerical model has been developed and is being exercised using the experimental data as a reference case. The goal of the project is to have a full set of scaling relationships developed for netting within two years. This will improve confidence in load and motion characteristics predicted from scale model tests for offshore aquaculture systems.

Research team: Bruce Colbourne, Wayne Raman Nair, Pengfei Liu, Shin Chin and Cheslav Balash. Submitted by NRC. For information contact Bruce Colbourne (Email: D.Colbourne@nre.cnre.gc.ca).

BC study compares natural and synthetic pigments

Which is better for the fish? Which is better for the bottom line?

Dr. Fiona Cubitt by one of her experimental tanks

A four-month study conducted through the Centre for Aquaculture and Environmental Research at the University of British Columbia confirms that farmed chinook salmon derive significant benefits from astaxanthin being added to their feed.

Carotenoids – the family of pigments to which astaxanthin belongs – have previously been identified as enhancing both survival and antioxidant function in fish.

But the study, part of a much larger interdisciplinary project regarding the costs and benefits of a potential organic aquaculture industry for Canada, has yet to have all of its data collated, tabulated and analysed.

As a result, says principal investigator and research associate Dr. Fiona Cubitt, there are only a few preliminary observations which can be made.

One of those, she indicated, is that young chinook salmon typically do not start taking up the pigmentation – whether from a natural source or a synthetic source – until the fish have reached a certain point in their development.

In general, said Cubitt, they don't begin taking it into their flesh until they reach roughly 100 grams.

When they do, said Cubitt, there is a marked difference in color between the larger and smaller fish and between those fed the pigment and those on a control diet with no pigment.

Researchers at the centre started growing nine groups of chinook salmon in separate 4,000-litre outdoor tanks at the facility in June 2006, beginning with fish of about 50 grams. By mid-September, the halfway point in the study, they had grown to an average of 110 grams, and were expected to rise to close to 200 grams by the end of the project.

The program is designed mainly to draw comparisons between natural- and synthetic-source astaxanthin as flesh-pigmenting materials for post-smolt chinook, looking at a variety of factors such as industry costs, as well as health and growth benefits. The feed additive is known to provide antioxidant health benefits, but concerns have been raised about the two potential sources for it: from krill in the wild, or from purely synthetic methods of production.

In order to investigate issues associated with organic aquaculture, Cubitt and her associates looked at both synthetically synthesized astaxanthin and astaxanthin made from natural sources using Phaffia yeast. The fish were sampled for assessment every eight weeks, with data taken on length, weight, growth, pigmentation, and condition factors – using health and welfare indicators.

With the aid of fish nutritionist Dr. David Higgs, the researchers made up their own feeds with ingredients obtained from companies such as EWOS Canada, mixing the materials, adding fish oil and making their own pellets.

The fish were hand-fed to satiation morning and afternoon, and Cubitt said it was very important to calculate the exact amount of the different kinds of feed each population of fish was eating.

"There have been three of us doing the feeding, so it has been a pretty labour-intensive project," said Cubitt.

Cubitt noted that both astaxanthin and castaxanthin, both of which are used in salmonid aquaculture, are naturally-occurring substances shown to enhance liver and antioxidant function in fish, and conventional fish-farming practice has been to use the two compounds generated from synthetic sources.

Cubitt said though that as fish farmers have increasingly demanded the antioxidants from natural sources, the variety, predictability, cost and quality of those products have also climbed. It has also been suggested that they aren't as effective or predictable as the synthetically-produced pigments – and so may not give the same health benefits. It's that which has led to an investigation to look at the effects of one of the newest natural-source astaxanthin (products) on the market, in a commercial replicated comparison between synthetically- and naturally-produced astaxanthin.

Research team: K.F. Cubitt, A. Chan, J. Mann, J. Henry, S. McKinley and D.A. Higgs. Contacts: kfcubitt@interchange.ubc.ca or higgsd@dfo-mpo.gc.ca. Agency submitting summary: DFO/UBC Centre for Aquaculture and Environmental Research.

Jun.-Nov.'06

Researchers study fate of fish pellets on seabed floor

Dr. Terri Sutherland spends a lot of time watching how different feed pellets react to different flows in a laboratory water-circulation system.

Sutherland is the principal investigator in an ongoing project to eventually put together a chart or matrix of what different sizes and types of fish-feed pellets do once they've passed through the fish pens and settled on the ocean floor.

Sutherland, a research scientist at the Centre for Aquaculture and Environmental Research run by the Department of Fisheries and Oceans and the University of British Columbia in Vancouver, initially did some field work on the subject in Maine during the mid-1990s.

Now she and colleagues at the centre and at the University of Southampton in England are refining some of that early work to help fish farmers and others predict more accurately how both feed and fecal waste from the farms will be dispersed over the ocean floor.

The factors that have to be taken into account are quite complex and not necessarily in direct relationship to each other, says Sutherland; and the project has just started to tie some of them together in the hope of one day coming up with a matrix of predictions which can be used in conjunction with the farm-footprint modelling system, Depomod, used by DFO.

Generally speaking, Sutherland said, the rule is that the larger the diameter of the coated pellet, the faster it settles to the bottom and the more effort it will take to put it back into suspension.

What's more, says Sutherland, different diets make pellets of different densities; water varies in density between summer and winter temperatures; and the extent to which the pellet will "stick" to the ocean floor will depend on the topography and composition of the substrate, whether it is clay or silt, rock or sand.

Sutherland says that the researchers have been putting different kinds of substrate into the bottom of a special circular laboratory flume which has a viewing panel in the side which allows the motion of the pellets to be videotaped. The plastic device, which is also fitted inside with measuring devices, was designed by Dr. Carl Amos and developed for studies by the Geological Survey of Canada and the University of Southampton. The researchers also have a similar version of the flume, which can be dropped to the ocean floor below a farm site.

To date, said Sutherland, she and her colleagues have looked only at winter feeds of different sizes – from 3.5 to 11 mms in diameter – from Skretting, but she said they intend to look at summer diets next year.

Additional work will also be done on analysing the chemical composition of the pellets for water, organic, carbon and nitrogen content, as well as stable carbon and nitrogen isotopes, and identifying potential tracers of waste material.

Research team: T.F. Sutherland, C.L. Amos, C. Ridley, I.C. Droppo, S.A. Petersen. Agency submitting the summary: DFO/UBC Centre for Aquaculture and Environmental Research. For information contact T.F. Sutherland (sutherlandt@pac.dfo-mpo.gc.ca).

DFO research vessel and feed-detection system on fish farm.

Dr. Sutherland with circular flume.

Early prediction of harmful algae blooms in New Brunswick

Training of farm staff in the collection and identification of phytoplankton.

This project investigated the feasibility and cost-effectiveness of several potential early warning approaches for predicting harmful phytoplankton blooms at salmon farms. The components of this project included: training farm personnel on the identification of harmful algal species; implementing daily phytoplankton monitoring by farm staff at selected salmon farms in southwestern New Brunswick; retrospective analyses of existing monitoring data; laboratory experiments to determine threshold concentrations of selected harmful phytoplankton species which cause problems for farmed salmon; water circulation studies to determine the spatial and temporal origin of water (which could transport phytoplankton blooms) entering salmon farms; evaluation of the effectiveness of a light sensor array for bloom detection; and evaluation of the usefulness of satellite imagery for bloom detection. The field and laboratory programs were completed in 2004 and 2005, with the collaboration of 4 salmon farms in each year. Data analysis and report preparation are mostly completed and the project will end in March 2007.

Research team: Blythe Chang (SABS, DFO) Jennifer Martin, Fred Page, Les Burridge, Murielle LeGresley, Alex Hanke, Paul McCurdy, Glen Harrison, Ed Horne. For information contact Blythe Chang (Email: changb@mar.dfo-mpo.gc.ca). Submitted by DFO (ACRDP)

Jun.'04-Mar.'07.

Testing recombinant vaccines for fish aquaculture

DNA vaccines are synthetic DNA constructs. They are taken up by the host cell, transcribed into immunogenic proteins and released into circulation where antigen presenting cells will take them up.

Infectious diseases present a significant economic burden to finfish aquaculture industries and there is concern that diseases may also negatively impact wild fish populations. Fish vaccines are used against various diseases and have reduced the environmental impact of diseases and improved animal welfare. However, few anti-viral vaccines are available leaving the industry without tools to prevent many viral diseases.

DNA vaccines are an alternative to traditional vaccines offering some advantages, e.g. safety, activation of several immune mechanisms in the host, multivalent vaccination possibility, high stability, relatively low cost, etc. However, these promising DNA vaccines are still in the early stage of design, evaluation and regulation.

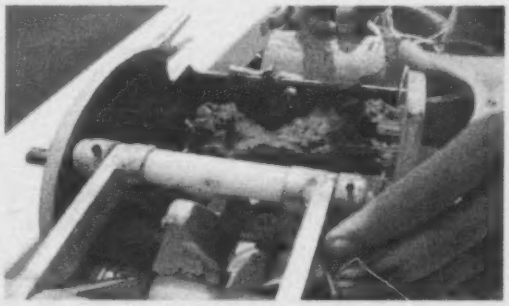
Heat shock proteins (HSP) are abundant in cells where they are involved in protein conformation and shuffling. One of their functions is to present antigenic peptides to the immune cells thus triggering an immune response.

In this project, we propose a novel approach for DNA vaccines where we will combine, in a single recombinant DNA plasmid, a sequence for an antigen and a heat shock protein from the host species. A leader sequence is also included in the vector to ensure secretion of the protein from the host cells. As a model disease-host system we selected Nodavirus and Atlantic cod. Different design and delivery approaches will be evaluated during the project.

Research team: Nellie Gagné (DFO), Stewart Johnson (NRC IMB), Laura Brown (NRC IMB), Luis Afonso (NRC IMB). Submitted by DFO (ACRDP). For information contact Nellie Gagné (Email : gagnena@dfo-mpo.gc.ca).

Apr.'06-Mar.'08

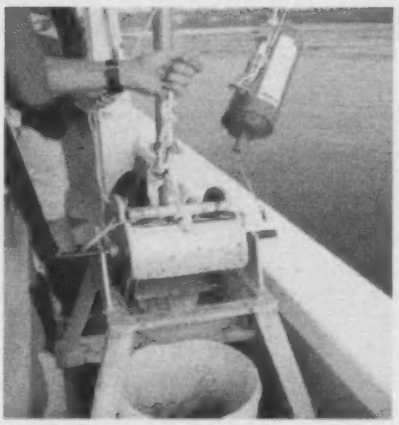
Management of organic waste & oxygen depletion at salmon farms in New Brunswick



The primary objectives of this project are to examine organic waste deposition and dissolved oxygen depletion around selected salmon farms in the southwestern New Brunswick (SWNB) area of the Bay of Fundy. Current meter deployments and a circulation model will be used to determine the water circulation regime around the farms. Benthic sediment samples will be collected and used, together with existing sediment data, to map the distribution of organic loading in the benthic environment below and around the farms. Data on local bathymetry, farm layout, fish production, feeding and settling rates of organic particles, in conjunction with estimates of water velocity, will be used to test the Scottish DEPOMOD aquaculture waste model. We will also link a particle settling routine to an existing three-dimensional tidal circulation model for the SWNB area. The model results will be compared to the actual benthic data to determine the suitability of these models for predicting organic waste deposition at fish farms in the SWNB area.

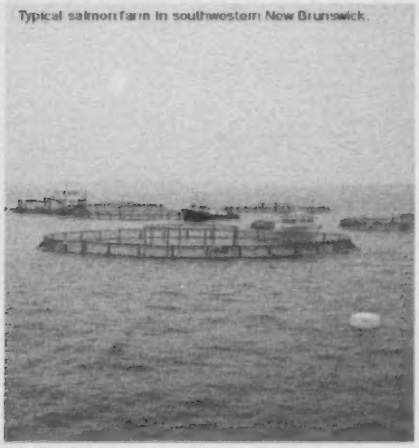
In addition, a simple flux balance numerical model will be used to predict the oxygen concentration within a farm using knowledge of the oxygen concentration at a distance from the farm, the velocity of the current entering the farm, the biomass, size structure and stocking density of the fish within the farm and literature-based estimates of the respiration rates of salmon. The model predictions will be compared with measurements of the temporal and spatial variability of dissolved oxygen levels in the water column within and around the selected salmon farms.

Research team: Fred Page, (SABS, DFO), Blythe Chang, Randy Losier, Paul McCurdy, Joe Crocker. For information contact Fred Page (Email: page@mar.dfo-mpo.gc.ca). Submitted by DFO (ACRDP). Nov.'05-May'08.



The photos show sediment sampling methodology used at salmon farms in southwestern New Brunswick.

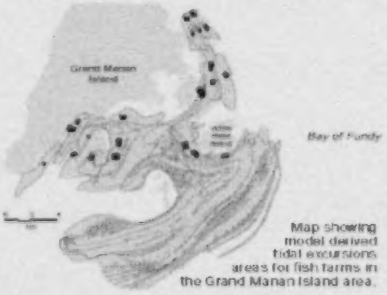
Evaluation of "Bay Management Areas" for southwest New Brunswick salmon aquaculture



Typical salmon farm in southwestern New Brunswick.

The *Sustainability Plan for Atlantic Canada Salmon Farming* (published in 2005) noted that "marine sites need to be organized relative to a system of effective bay management areas, based on biophysical environment and risk management (fish health, environment) and infrastructure needs." A workshop held in July 2005 by the salmon farming industry noted that there were several key facts that must be addressed when making improvements to the existing system of Bay Management Areas (BMAs) to support the *Sustainability Plan*. These include hydrodynamics and circulation, fish health, integration of alternate species, infrastructure, stakeholder interactions, fallow times, balancing production, and supporting growth.

The objectives of this project are to produce a series of two dimensional GIS based maps describing the spatial distribution of aquaculture sites, potential zones of aquaculture impact (i.e. simple estimates of waste dispersal plumes), disease plumes from salmon farms (i.e. tidal excursions) and the distribution of major fishery resources and activities in the coastal zone of the southwest New Brunswick area. The GIS maps will be used to determine the site specific and cumulative overlaps between aquaculture sites and their zones of potential influence with respect to disease and waste dispersal with the major resources and harvesting activities. The cumulative overlaps will be produced for each of several BMA boundary scenarios that will be provided by the salmon industry.



Map showing model derived tidal excursions areas for fish farms in the Grand Manan Island area.

Research team: Fred Page (SABS, DFO), Blythe Chang, Randy Losier. For information contact Fred Page (Email: page@mar.dfo-mpo.gc.ca). Submitted by ACRDP DFO.

Nov.'05-May'07

Susie Huang (M.Sc. Student, UBC) showing separation of crumbled pelleted feed into different fractions for fish of different sizes.

Researchers examine canola oil as a lipid source for chinook pre-smolt

A nutrition study was undertaken to determine how the inclusion of different concentrations of canola oil (CO) in the diets of spring chinook salmon (*Oncorhynchus tshawytscha*) by progressive replacement of anchovy oil affected the growth, health, ionoregulatory development, sea water tolerance, swimming performance and whole body and lipid composition of the fish before and after transfer into sea water. Triplicate groups of spring chinook salmon (initial weight, 0.42-1.9g) were fed one of four isonitrogenous and isoenergetic diets that contained one of four levels of canola oil (CO furnished either 0%, 25%, 50% or 75% of the total dietary lipid content).

Over a 7 month period, diet treatment was not found to significantly affect fish growth, ionoregulatory ability, swimming performance or any aspect of fish health (haematology and immunology). Thus, canola oil was found to be an excellent source of dietary lipid for spring chinook salmon during most of the freshwater residency period of this species. Owing to the rising costs of fish oil in the world commodity market, these findings are of great significance for feed manufacturers and private and government producers of chinook salmon smolts.

Research team: Susie Huang, Colin Brauner, Trish Schulte, Shannon K. Balfry, and Dave A. Higgs. Submitted by DFO (ACRDP). For information contact Dave Higgs (Email: higgsd@dfo-mpo.gc.ca).

May-Dec.'05

Determining the immune response of Atlantic salmon to infectious salmon anemia virus (ISAV)

Infectious diseases present a significant economic burden to finfish aquaculture industries and there is concern that diseases may also negatively impact wild fish populations. Increasingly, genomic tools are being used to investigate diseases of fish and their causative agents and are beginning to provide scientists, clinicians and regulators with management options. Despite this, very little is known about the diseases and pathogens affecting Canadian finfish culture industries or adjacent wild populations.

Infectious salmon anemia virus (ISAV) is an important virus pathogen of salmonids and causes mass mortalities. It remains a recurrent problem in Eastern Canada and Maine since the initial epizootics of 1996.

In this project, we propose a genomic approach to better understand the diversity of ISAV and to relate this diversity to host responses to infection, the development of disease and the recovery from or resistance to, clinical disease. ISAV isolates will be selected according to their pathogenicity. Atlantic salmons will be exposed to the virus and microarray technology will be used to discover molecular biomarkers of viral infection and resistance mechanisms against ISAV.

Research team: Nellie Gagné (DFO), Philip Byrne (DFO), Kyle Garver (DFO), Simon Jones (DFO). Submitted by DFO (ACRDP). For information contact Nellie Gagné (Email: gagnena@dfo-mpo.gc.ca).

Apr.'05-Mar.'08

Evaluation of feed attractants for chinook salmon

A study is being undertaken to assess the efficacy of various marine protein products as palatability enhancers for salmon. Two types of experimental fish protein hydrolysates (FPH) prepared from Pacific hake (*Merluccius productus*) using commercially available enzymes along with two commercially-prepared FPH's and a krill product are being tested for their feed attractant qualities using juvenile chinook salmon (*Oncorhynchus tshawytscha*) in a 35 day study.

Control salmon are being fed a fishmeal and oil based diet whereas experimental salmon are receiving diets containing soybean meal at a concentration known to depress appetite without or with an identical concentration of each of the aforementioned putative palatability enhancers. It is hoped that one or more of the test palatability sources will partially or fully mask the anti-palatability effects of the constituents originating from the soybean meal and thereby permit more extensive use of this inexpensive plant protein source in diets for this species. Also, we hope that the most effective diet palatability enhancer(s) identified in this study will prove useful for other salmonid species such as Atlantic salmon fed diets extensively based upon plant protein sources. These results may also yield an alternative use for the highly undervalued Pacific hake.

Research team: T. Ho, B. Skura, D.A. Higgs, E. Li-Chan, and B.S. Dosanjh. Submitted by DFO (ACRDP). For information contact Dave Higgs (Email: higgsd@dfo-mpo.gc.ca).

Sept'06 ongoing

Tom Ho feeding experimental chinook salmon (M.Sc. Student, UBC).

New Brunswick research to characterize strains of ISA in Bay of Fundy

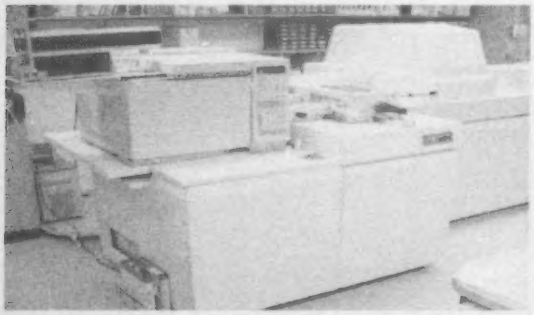
In recent months the ISAV surveillance program operated by the New Brunswick Department of Agriculture, Fisheries and Aquaculture has identified a preponderance of salmon infected with genetically distinct ISAV strains, both of North American and European descent. Some of which seem to be more virulent than others. The apparent disparity in virulence makes management decisions on infected fish difficult in light of many unanswered questions. The existence of different strains, which may or may not be possible to detect with all exiting diagnostics assays, and the inability of these routine assays to differentiate between strains of variable virulence complicates the management of ISAV. Therefore, studies are needed to further characterize isolates at the genetic level and to determine the virulence differences between ISAV strains so that i) rapid economical and improved assays for the differentiation of strains in routine surveillance programs can be developed and ii) intelligent and cost-effective management of the disease can occur.

In this project, ISAV isolates collected during 3 months of surveillance in the Bay of Fundy were characterized at the gene level. Field observations at the cage level, including mortality, were correlated to the genotype of ISAV causing the infections. These isolates were also used in controlled challenges of Atlantic salmons. Various factors such as mortality rate and viral load will be measured during the experimental challenges.

Research team: Nellie Gagné (DFO), Rachel Ritchie (RPC), Sandy McGeachy (NBDAFA), New Brunswick Salmon Grower's Association. Submitted by DFO (ACRDP). For information contact Nellie Gagné (Email : gagnena@dfo-mpo.gc.ca).

Jan.-Mar.'06

Examining organohalogen concentrations in farmed salmon: a field trial



Analytical equipment at the DFO Institute of Ocean Sciences used for measurement of organohalogen compounds.

This project addresses the urgent need from a public perception standpoint to reduce substantially the concentrations of organohalogen contaminants in the flesh of farmed salmon. Alternative commercially produced diets in which fish oil is significantly replaced by poultry fat, canola oil or blends of these lipid sources, are being fed to farmed salmon in sea pens. It was postulated at the outset of this study, that the alternative diets would dramatically reduce the contaminant concentrations below the range noted for these compounds in wild salmon species and orders of magnitude lower than the national and international guidelines currently in place for human consumption.

Concurrently, we are attempting to show in this field trial that the alternate diets are maintaining adequate flesh levels of n-3 highly unsaturated fatty acids which are known to have human health benefits. Recent results from this collaborative study between DFO researchers and Marine Harvest indicate that PCB concentrations in the flesh of market size farmed Atlantic salmon can be decreased by up to 10 times when the fish are fed with alternate diets which aren't extensively based on fish oil. These results along with those from a laboratory study should calm negative public perceptions of farmed salmon flesh quality.

Research team: M. Ikonomou, E. Friesen, D.A. Higgs, and Keng Pee Ang. Submitted by DFO (ACRDP). For information contact Michael Ikonomou (Email: ikonomoum@dfo-mpo.gc.ca).

Jul.'05 Jun'07

Tracking & characterizing VHS in Canada

VHSV is a highly pathogenic aquatic rhabdovirus that causes devastating losses in wild and cultured fish in Europe, North America and Japan. VHSV infections occur in a broad host range, cause significant economic impact and are listed as notifiable by the Office International des Epizooties (O.I.E). Over the last decade VHSV has been isolated from an increasing number of wild and cultured marine fish populations in the North Pacific and North Atlantic Oceans, and more recently from freshwater fish species in the North American Great Lakes watershed. These novel isolations extend the host and geographic range of VHSV in North America and illustrate the potential impact on fish populations.

To better understand the epidemiology and evolution of VHSV, this study will characterize the genetic diversity of virus isolates taken from marine and freshwater environments of North America. The pathogenicity of viral genetic variants will be assessed and a genomics approach will be utilized to better understand the host response to infection, the development of disease and the recovery from or resistance to, clinical VHSV disease.

Research team : Kyle Garver, Simon Jones, Philip Byrne, and Nellie Gagne. Submitted by DFO (ACRDP). For information contact Kyle Garver (Email: garverK@pac.dfo-mpo.gc.ca).

Apr.'05 Apr.'08

Researchers reduce flesh contaminants in farmed Atlantic salmon

Janice Oakes filleting an Atlantic salmon for subsequent measurement of organohalogen compounds.

A nutrition study was conducted on post smolt Atlantic salmon to (1) dramatically reduce flesh concentrations of persistent organic pollutants to the lowest levels seen in wild salmon by chronic feeding of diets extensively based on plant and/or animal lipids and, in two cases, plant protein concentrates with contaminant-reduced fish oil and (2) re-instate flesh concentrations of fatty acids of importance for human health in the market-size product to levels observed in wild salmon.

The study was conducted in two phases. In phase 1 (24-weeks), the alternate dietary sources of lipids and proteins to conventional fish oil and fishmeal were employed. In phase 2 (12 weeks), the flesh concentrations of fatty acids essential for human health (DHA and EPA) that were lowered by the treatments in phase 1, were raised by feeding the salmon finishing diets supplemented solely with conventional or contaminant reduced fish oil. The test dietary lipid and protein sources generally did not influence the growth performance of the fish during phase 1 of the trial relative to fish fed the fishmeal and oil based control diet. This finding will result in important cost savings for the BC salmon farming industry.

Determinations of flesh organohalogen concentrations, and fatty acid compositions are in progress. The findings of this study should allay public concerns regarding the flesh quality of farmed Atlantic salmon from a contaminant and fatty acid perspective.

Erin Friesen (Ph.D. student, UBC).

Research team: E. Friesen, D. Higgs, M. Ikonomou, B. Skuza, A.P. Farrell, S.K. Balfry, J. Oakes, J. Mann, G. Deacon and D. Macrae. Submitted by DFO (ACRDP). For information contact Dave Higgs (Email: higgsd@dfo-mpo.gc.ca).

Jul.'05 Mar.'06

Scientists investigate effect of oxidizing dietary lipids on Atlantic salmon

A 12-week study was conducted on small (4g) Atlantic salmon (*Salmo salar*) to assess the potential adverse consequences of actively oxidizing dietary lipid on the growth, health (haematological and immunological parameters), histopathology, whole body composition, and vitamin E content as well as levels of oxidation products (TBARS).

The salmon were fed daily to near satiation (first 28 days) or to satiation (last 56 days) steam pelleted isonitrogenous and isoenergetic dry diets that were supplemented with either unoxidized or pre-oxidized herring oil as measured by the peroxide value (PV; <2 or <2+, 30+, or 50+ meq/kg). Lipid peroxidation in the fishmeal and fish oil was controlled by adding ethoxyquin (150 mg/kg) to the diets that contained the unoxidized lipid (<2 meq/kg). All other diets lacked ethoxyquin and accordingly underwent active oxidation (+). All diets on day 0 contained at least the required level of vitamin E (30 IU/kg). On day 84, vitamin E concentrations were reduced in all diets and those with an initial PV of 30+ and 50+ had significantly lower levels of this vitamin than diets with an initial PV of <2 and <2+. A primary paper reporting these findings will be submitted for publication in November or December, 2006.

Jill Sutton on site at DFO/UBC Centre for Aquaculture and Environmental Research.

Research team: J Sutton, S.K. Balfry, G. Marty, J. Mann, B. Hicks, W. Kay and D.A. Higgs. Submitted by DFO (ACRDP). For information contact Dave Higgs (Email: higgsd@dfo-mpo.gc.ca).

Jul-Oct.'06

Atlantic salmon egg research

The British Columbia Atlantic salmon farming industry relies on eggs from resident broodstock. To date the survival and quality of eggs in the industry has not been optimal. This project has examined a number of hatchery production protocols in order to determine methods and techniques to improve handling and increase survival of eggs.

The following research was conducted on Atlantic salmon eggs:

- Mechanical shock
- Mechanical shock & iodine disinfection
- Gamete storage and transport, including minimum sperm density assessment
- Incubation in a range of temperatures from 3 to 14 °C
- Temperature transfer from 8 to 10, 12, & 14 °C at "eyed" and hatch.
- Respiration measurements at 8, 10, & 12 °C

Closeup of an Atlantic salmon embryo, note the developing pectoral fin and gill arches (52 days post-fertilization at 6 °C).

Four progress reports (available upon request) were presented at the Northwest Fish Culture Conference, held in Victoria, BC on Dec. 7-9, 2004. Further analyses are ongoing and a complete published report anticipated in 2007.

Mathematical models of embryonic development for Atlantic salmon have been incorporated into a fish culturist computer program called WinSIRP.

Atlantic salmon egg at the 4-cell stage (20 hours post-fertilization at 10 °C).

Atlantic salmon embryo at the eyed stage (604 hours post-fertilization at 12 °C).

Research team: John Jensen (DFO), Maureen Lawrie (Pan Fish Canada Ltd.), Jamie Gaskill (Marine Harvest Canada Ltd), Bill Damon (DFO), Ted Sweeten (DFO), Joan Bennett (DFO), Bill Mclean (DFO), Jack Smith, Karin Davis.

Submitted by DFO (ACRDP). For information contact John Jensen (Email: jensenj@pac.dfo-mpo.gc.ca). Website http://www-sci.pac.dfo-mpo.gc.ca/aqua/sirp/sirp_e.htm OR http://www.sci.pac.dfo-mpo.gc.ca/aqua/sirp/sirp_f.htm

Apr.'03-Jun.'06

Researchers investigate influence of dissolved gases & temperature on Atlantic salmon broodstock

The British Columbia Atlantic salmon farming industry relies on high quality gametes from resident broodstock. It is suspected by the salmon farming industry that dissolved gas levels in sea pen broodstock holding facilities and transportation tanks may be adversely affecting the maturation process and causing poor egg quality and larval abnormalities.

Ongoing tests at the Pacific Biological Station in Nanaimo, BC, using a unique degassing system designed for up to 400 LPM flow through, have shown that low oxygen levels (i.e. as low as 4 mg/L oxygen) have a direct impact on the broodstock by increasing pre-spawning mortality, influencing the release of sex and stress hormones during the maturation process (i.e. vitellogenesis and ovulation), and reducing egg production and viability. The adverse influence of high water temperature during maturation is also being tested. Finally, the adverse effects of carbon dioxide build up during fish broodstock transport in closed systems are of concern to the salmon farming industry and tests to filter out or reduce this metabolite are being conducted.

Research team: John Jensen (DFO), Maureen Lawrie (Pan Fish Canada Ltd.), Jamie Gaskill (Marine Harvest Canada Ltd.), Bill Damon (DFO), Ted Sweeten (DFO), Bill Mclean, Jack Smith.

Submitted by DFO (ACRDP).

For information contact John Jensen (Email: jensenj@pac.dfo-mpo.gc.ca).

Apr.'05 Jun.'07

Top right: Obtaining blood sample for hormone analysis.

Below right: Atlantic salmon broodstock being transferred to holding tanks at the Pacific Biological Station, Nanaimo, BC.

Left: Vacuum degassing column used to reduce dissolved oxygen levels to 4 ppm.

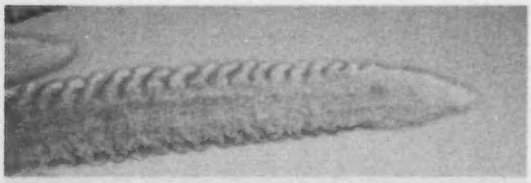
Testing RNA versus DNA-based detection of Atlantic salmon parasites

Quantitative PCR (QPCR) methods targeting the 18S rDNA gene (DNA QPCR) and cathepsin L mRNA (RNA QPCR) from *Kudoa thyrsites* (Gilchrist) were developed and compared to histology for determination of *K. thyrsites* infection levels in Atlantic salmon, *Salmo salar* L. Both QPCR tests were specific, reproducible and sensitive down to three copies. However, DNA QPCR was able to detect lower *K. thyrsites* infection levels than RNA QPCR and histology. The higher threshold for *K. thyrsites* infection levels detectable via RNA QPCR compared to DNA QPCR appeared to be biological in nature, indicating that fewer copies of cathepsin L mRNA compared to 18S rDNA genes were present in the samples. However, all three diagnostic methods were highly correlated. Regression analyses comparing DNA QPCR and histology data from two distinct groups of fish showed that the relationship between these two diagnostic methods was reproducible. A logistic regression analysis comparing diagnostic data to a visual assessment of post mortem flesh quality indicated that histology was the single best predictor of flesh quality, followed by DNA QPCR and then RNA QPCR.

Left: Atlantic salmon fillet infected with *Kudoa thyrsites*.
Right and Lower Right (both): *Kudoa thyrsites plasmodia and spores.*

Research team: Valerie Funk, Monique Raap, Ken Sojonky, Simon Jones, John Robinson, Christy Falkenberg, Kristi Miller. Submitted by DFO (ACRDP). For information contact Kristi Miller (Email: millerk@pac.dfo-mpo.gc.ca).

Apr.'04-Aug.'06



A Diagnostic tool for early detection of gill parasites in Chinook salmon

In this project we are developing an Enzyme Linked Immunosorbant Assay (ELISA) designed to be used as a diagnostic tool for the detection and quantification of *Loma salmonae* infection in Chinook salmon (*Oncorhynchus tshawytscha*). ELISA utilizes highly sensitive and specific antibodies (Ab) for pathogen detection.

Polyclonal egg yolk antibodies (IgY) were generated by immunization of chickens with purified *L. salmonae* spores. Polyclonal IgY was extracted from egg yolks beginning at 28 days post immunisation (PI). Purity of extracted IgY was confirmed by SDS-PAGE and western blots of yolk protein extracts. Reactivity of the IgY preparation to *L. salmonae* was determined through indirect fluorescence antibody tests on purified spores. The IgY preparation was found to be pure and highly sensitive and specific for *L. salmonae* by immunohistochemistry. Biotinylation of capture antibodies was confirmed through dot blotting.

ELISA development is ongoing; however the IgY preparation has shown to be useful for the detection of early *Loma salmonae* development in Pacific salmon. Immature xenomas in histological sections of heart and gill tissue of infected Chinook salmon (*Oncorhynchus tshawytcha*) were visualised as early as 4 weeks post-exposure (PE) by immunohistochemistry. Non-lethal, early detection of *L. salmonae* was obtained by indirect fluorescent microscopy of acetone fixed gill clips.

Research team: Simon Jones (DFO). Submitted by DFO (ACRDP). For information contact Simon Jones (Email: JonesS@pac.dfo-mpo.gc.ca). Aug.'05-Dec.'06

East Coast researchers test furunculosis vaccines for Atlantic salmon

The Bay d'Espoir strain of atypical furunculosis has caused significant financial losses for salmonid farms in Newfoundland. Although much research has been done on furunculosis of salmonids, the Newfoundland Salmonid Growers Association (NSGA) has been anxious to quantify the efficacy of existing furunculosis vaccines under Bay d'Espoir conditions and determine if development of new fish health intervention tools is warranted. A proactive and visionary research program was implemented in 2001 to characterize the nature of the pathogen itself, investigate possible alternative treatments for controlling the pathogen, and the potential for development of new vaccines should the efficacy of existing vaccines prove limited.

The first two years of the research initiative established the taxonomy of the bacterium, its severe pathogenicity, and a disease-challenge model with which to determine commercial-vaccine efficacy under laboratory and field conditions. In 2003 and 2004, the vaccine study was performed using controlled laboratory challenges that quantified vaccine efficacy in the laboratory and provided the criteria on which to base selection of vaccines for field trials. Literature reviews have been conducted in the area of usage of both bacteriophage and immunostimulants as alternative health management tools. The research for 2004 - 2006 draws on those laboratory results to conduct actual field trials to the Bay d'Espoir strain of *Aeromonas salmonicida* subspecies *nova* at actual Bay d'Espoir salmon farms.

Research team: Atef Mansour, Larry Hammell, Daryl Whelan, and Gilles Olivier. Submitted by DFO (ACRDP). For information contact Atef Mansour (Email: Mansoura@dfo-mpo.gc.ca).

Jun.'01-Mar.'06

Can new vaccines reduce *KUDOA* infection in Atlantic salmon?

Kudoa thyrsites (Myxozoa; Myxosporea) infections have no apparent affect on the fish host while the fish is alive but severe infections in farm reared Atlantic salmon result in deterioration of fillet musculature post-mortem and an unmarketable product.

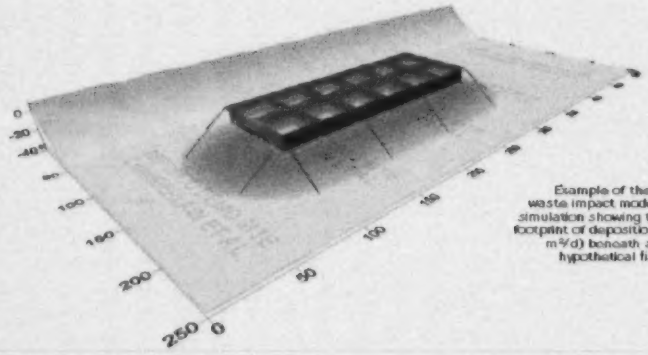
Two recombinant subunit vaccines were tested for their ability to elicit an immune response and to reduce *K. thyrsites* infection levels in Atlantic salmon. Both vaccines elicited a long-lasting specific antibody response and a reduction in the number of parasites compared to the saline control group as determined by quantitative PCR and histological examination. The treatment effect was evident up to 1200 degree-days post-exposure of vaccinated fish to the parasite corresponding to 1800 degree-days post vaccination. In addition, the parasite was detected in a smaller proportion of vaccinated fish compared to controls when using histology as the diagnostic method.

There was evidence that the vaccine adjuvant contributed to the observed efficacy as both diagnostic methods found that average *K. thyrsites* infection levels were highest in fish injected with saline and lowest in those receiving adjuvant only. These results support the use of these novel, cost effective recombinant subunit vaccines for reducing *K. thyrsites* infection levels in farm reared Atlantic salmon.

Research team: Valerie Funk, Kristi Miller, Jan Burian, Simon Jones. Submitted by DFO (ACRDP). For information contact Val Funk (Email: valfunk@telus.net).

Apr.'05-Mar.'06

DEPOMOD parameter setting and validation for finfish farms in BC



Example of the aquaculture waste impact model DEPOMOD simulation showing the predicted footprint of deposition (g Carbon/m²/d) beneath and around a hypothetical fish farm site.

The initial ACRDP-BCSFA project undertaken during 2004-2005 successfully demonstrated the utility of the waste model DEPOMOD in predicting the effect of marine cage finfish farms on near-field seabed conditions. Significant correlations between predicted relative carbon flux and several measures of benthic effect were observed at one B.C. farm site. However, the investigation identified data limitations and deficiencies in several key parameter settings used in the model. Additionally, all correlations were calculated using model outputs where resuspension processes had not been simulated. The resuspension model in DEPOMOD, when applied, predicted that virtually all of the applied material was exported from the model domain and precluded comparisons of model output with observations.

The results of this project were presented at the DFO peer review meeting (Feb'05) on National Science Advice for Finfish Cage Aquaculture and published as a Canadian Science Advisory Secretariat paper. The recommendations of this paper and meeting identified several research priorities; further validation of the model at different sites; determination of waste feed rates; assessment of the carbon concentration in feed and faecal material; investigation of the importance of resuspension processes; and determination of cage movement due to currents and winds. This project addresses the above research recommendations.

Research team: Dario Stucchi (DFO), Jon Chamberlain (DFO), Mary Ellen Walling (BC Salmon Farmers Association) and Barron Carswell (BC Ministry of Agriculture and Lands). Submitted by DFO (ACRDP). For information contact Dario Stucchi (Email: StucchiD@pac.dfo-mpo.gc.ca).

Sept.'05-Mar.'07

Developing a vaccine against microsporidial gill disease in salmon

Loma salmonae (Microsporidia) is the causative agent of microsporidial gill disease (MGD) that affects all species of Pacific salmon (*Oncorhynchus*) and is the leading cause of mortalities in farm reared chinook salmon. Research has shown that recovered chinook salmon develop immunity against future infections by *L. salmonae* thus validating efforts for vaccine development. Development of a recombinant subunit vaccine is the most promising approach for generating a commercially available vaccine against *L. salmonae*.

A first step in the development of a recombinant vaccine requires the elucidation of parasite derived protein sequences. This will be carried by generating a subtractive cDNA library using both *L. salmonae* infected and uninfected gill tissue. Immunochemistry and *in vitro* cellular assays will then identify parasite proteins that are recognized by the host and as such, most likely to provide immunity. The cDNA subtractive library will also lead to the identification of upregulated host genes in response to infection and provide the first direct information of host responses at the molecular level.

Research team: Valerie Funk, Angela Schultz, Simon Jones, Kristi Miller. Submitted by DFO (ACRDP). For information contact Kristi Miller (Email: millerk@pac.dfo-mpo.gc.ca).

Jul.'06-Mar.'08

Researchers investigate heritage of farm salmon in Bay of Fundy

Are they local or European in origin?

Previously published analyses have identified the presence of wholly European and European/North American hybrid salmon in aquaculture escapees obtained from Canadian waters in the Bay of Fundy (BoF) area. Most Canadian producers already screen their broodstock for European ancestry as part of the State of Maine regulations which prohibit stocking of non-North American fish in Maine waters, but some local growers which supply eggs and smolts may not. These non-screened collections were analyzed by an independent laboratory to test for European ancestry using methods developed by the USFWS and DFO.

Out of 400 aquaculture salmon surveyed, five salmon exhibited European type mitochondrial DNA and many carried European type nuclear alleles and were identified as having European ancestry by both DFO and USFWS methods. Of 314 wild salmon obtained from the Bay of Fundy area, four exhibited European-type mitochondrial DNA and two European-type nuclear alleles, though no individual exhibited more than a single European-marker, and none were identified in the DFO assay as European. Despite this, three wild fish were classified as non-North American using the USFWS method. This analysis indicates that in all but very rare instances, the USFWS test will be more stringent in identifying salmon as European than will the DFO test.

Research team: Rachael Richie, Patrick O'Reilly. Submitted by DFO (ACRDP). For information contact Rachael Ritchie (Email: Rachael.Ritchie@rpc.ca).

Sept.'04-Dec'06

Investigating gastric dilation, air Sacculitis syndrome in farmed steelhead trout

Steelhead growers in Newfoundland have experienced a serious performance problem in the recent past. The syndrome is known as Gastric Dilation, Air Sacculitis (GDAS) where the affected fish suffer from increased mortality, reduced growth, distended abdomens, silvering and a high number of fat droplets surfacing over the net pens. The frequency of GDAS seems to increase with an increase in water salinity and also when water temperature decreases. Other factors are related to nutrition and early maturation and possibly the genetics of the trout strain used in Bay d'Espoir, however no definitive cause is yet known. This prompted the industry to the possibility of obtaining a Danish Steelhead strain to grow.

To maximize the productivity of steelhead aquaculture in Newfoundland, Newfoundland Salmon Growers Association in collaboration with Fisheries and Oceans Canada and Newfoundland Department of Fisheries and Aquaculture are aiming to identify the possible causes of GDAS in farmed steelhead trout in Bay d'Espoir and to suggest possible mitigating measures. Standard diagnostic health testing will be performed as well as histopathological and biochemical indexes during the production cycle. Secondly, laboratory trials to reproduce GDAS will be conducted to identify the role of single and/or multiple factors in the development of the syndrome. Finally, a laboratory comparison between the currently used steelhead strains in Bay d'Espoir and those strains used in Denmark in relation to their susceptibility to GDAS will be performed.

Research team: Atef Mansour, Daryl Whelan, Christopher Parrish, Kurt Gamperl, Elizabeth Barlow. Submitted by DFO (ACRDP). For information contact Atef Mansour (Email: Mansoura@dfo-mpo.gc.ca). Aug.'05-Mar.'08

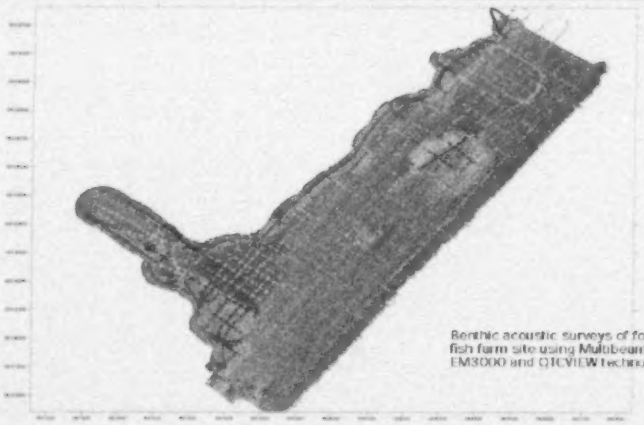
Using meiofauna to indicate benthic organic enrichment from salmon aquaculture

To date, the impact of fish farm wastes on the benthic environment has mainly been assessed in terms of changes in macrofaunal abundance and diversity. However, recent studies have examined the response of meiofaunal assemblages in regards to aquaculture-derived benthic organic enrichment. Meiofauna (63 to 500 µm) have been used to monitor organic enrichment gradients in association with other anthropogenic applications such as sewage outflows and oil spills. Meiofauna serve as sensitive indicators to environmental pollution as a result of their small size, interstitial existence, naturally-occurring high abundances, direct benthic recruitment, short generation times and asynchronous reproduction.

Collection of a grab sample by Shane Petersen.

The objective of this study was to assess the effects of varying levels of organic enrichment associated with aquaculture activities on benthic meiofaunal assemblages in a subtidal setting across a range of substrates within the Broughton Archipelago, British Columbia. Environmental sediment variables and meiofaunal samples were collected within the near- and far-field regions of four salmonid fish farms and one reference site. Delineating the relationship between free sulfide concentration and various meiofauna taxa was emphasized, since this geochemical measure has been previously shown to structure macrofauna communities and is the basis for an organic enrichment classification system recommended for environmental monitoring. Certain meiofaunal groups, such as, Kinorhynchs, Crustaceans, and Polychaetes, showed sharp declines in abundance in an asymptotic fashion with increasing free sulfide concentrations. Other groups, such as, Nematodes and Foraminifera, showed a general decline in abundance with increasing organic enrichment with a high amount of variability observed at high free sulfide concentrations. The ratio of Nematodes to copepods was shown to represent the degree of organic loading associated with aquaculture operations.

Research team: T.F. Sutherland, C.D. Levings, S. Petersen, P. Poon, and E. Piercey. Submitted by DFO (ACRDP). For information contact T.F. Sutherland (Email: sutherlandt@pac.dfo-mpo.gc.ca).



Benthic acoustic surveys of former fish farm site using Multibeam EM3000 and QTCVIEW technology.

Scientists ground truth acoustic technologies at BC farm site

Both acoustic and sediment surveys were carried out in the Broughton Archipelago, British Columbia, in order to map a former aquaculture site and calibrate the acoustic surveys with georeferenced sediment properties. The acoustic surveys included EM3000 Multibeam (including backscatter) and QTCVIEW (Series IV) technologies, while the geotechnical survey entailed Van Veen grab sampling of surface sediments and associated analyses.

The two acoustic technologies were consistent in their ability to identify distinct regions of seafloor characterized by rock outcrops, consolidated substrates, or gel mud depositional fields. Both Multibeam backscatter data and QTC-VIEW number-coded classifications were extracted across a range of circular areas located at each georeferenced sampling station (radii: 2, 3, 4, 5, 8, 12, 16, 20 meters). Statistical correlations between backscatter and number classifications were observed at the higher ranges of circular extraction areas, where sufficient data was collected from the single-beam QTCVIEW survey at each sampling location. Statistical correlations were observed between backscatter and certain geotechnical properties, such as sediment porosity, sediment grain size fractions (< 2-micron, < 100-micron, silt content), and particulate sulphide content.

The aerial resolution of backscatter extraction was explored in terms of determining a sensitive calibration technique between backscatter and sediment properties. In general the highest r^2 values between backscatter and sediment variables were observed across extraction radii between 8 to 20 meters. Such ground-truthing techniques could be used to interpolate seafloor characteristics between sampling stations and provide a steering tool for sampling designs associated with benthic monitoring programs.

Research team: T.F. Sutherland, J. Galloway, R. Loschiavo, C.D. Levings, and R. Hare. Submitted by DFO (ACRDP). For information contact T.F. Sutherland (sutherlandt@pac.dfo-mpo.

BC researchers test efficacy of IHN vaccine in Atlantic salmon

IHNV is an aquatic rhabdovirus that causes significant mortality in salmon and trout. In the marine environment, IHNV is highly infective, pathogenic and virulent for Atlantic salmon.

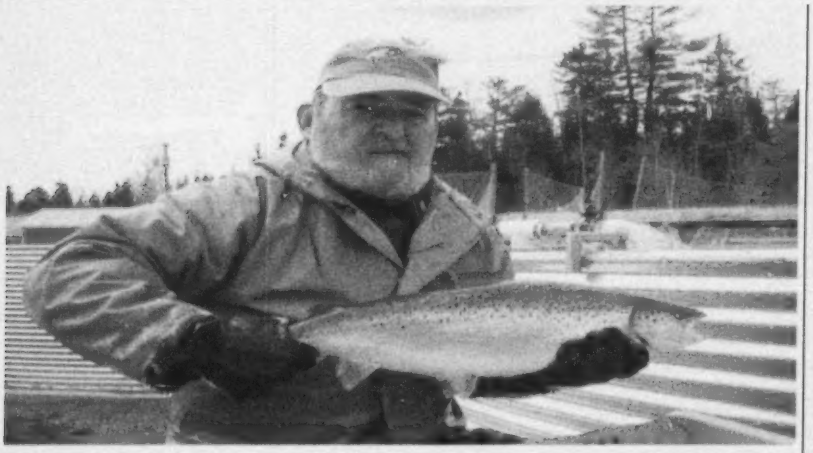
In British Columbia, IHNV is the most economically important viral pathogen of farmed salmonids. Since the introduction of Atlantic salmon to the BC coast in the mid 1980's, there have been two serious outbreaks of IHN in farmed Atlantic salmon: 1992-1996 and 2001-2003. During the latest epizootic, mortalities were greater than 70% in fish less than 1 kg and averaged 40-50% when fish were larger than 1 kg. Thirty-six farm sites were diagnosed with IHNV during this epizootic. The estimated economic loss resulting from both epizootics was $40 million in inventory representing $200 million in lost sales.

The source of the IHNV introduction to farmed salmon is unknown but epidemiological investigations have been useful in identifying potential mechanisms of virus transmission and have led to implementation of effective IHNV biocontainment strategies on farm sites. However, as in the case for other viral diseases, cyclical epizootics of IHNV are expected to continue to occur in farmed salmon. To interrupt the disease cycle, vaccines are required in addition to existing good fish health management practice tools. The goal of this study is to test the efficacy and duration of protection of an inactivated IHNV vaccine administered in combination with a multivalent bacteria vaccine used routinely by the industry.

Research team: Garth Traxler, Kyle Garver, Val Funk. Submitted by DFO (ACRDP). For information contact Garth Traxler (Email: traxlerg@dfo-mpo.gc.ca).

Jul.'06-May'08

Immunizing salmon with IHNV vaccine.



East Coast researchers compare performance of local and imported salmon strains at PEI facility

Recently, marine diseases, especially Infectious Salmon Anemia virus (ISAv), have resulted in the destruction of most seawater cage maintained broodstock in New Brunswick. This problem prompted a move toward maintenance of land-based broodstock to supply eggs. Hatchery reared pedigreed smolts are transferred to either freshwater or ground seawater supplied shore based tank fields. These smolts are retained for two years, selected individuals are spawned and the eggs returned to the smolt production hatcheries where they are on-grown to supply seedstock to the marine farms. This broodstock have the advantage of being isolated from Infectious Salmon Anemia Virus and other seawater disease exposure.

In this project, Dover Fish Farm (a disease free landbased broodstock site in PEI) is developing a pedigreed Saint John River (NB) stock to supply ISAv free ova to New Brunswick and else where. Furthermore, European pedigreed ova have been imported for comparative performance evaluation. If superior performance is demonstrated, all female triploid sterile ova could be supplied to New Brunswick and other Maritime farming areas to increase industry competitiveness. Similar markets for diploid and triploid European strains could be developed in BC, and Chile.

This project aims is to improve the competitiveness of the Atlantic coast salmon aquaculture industry by giving farmers better access to disease free ova as seedstock from the best strains. Furthermore, applying land-based broodstock methods reduces the risk of catastrophic broodstock loss due to disease in seawater cages.

Research Team: Ken and Leon Meyaart, Dover Fish Hatchery Ltd (PEI), Kang Pae Ang, Stolt Sea Farm Ltd. (BC) and Chris Mills, (DFO), Wilfred Young-lai. Submitted by DFO (ACRDP). For Information contact Brian Glebe (E-mail: GlebeB@mar.dfo-mpo.gc.ca).

Development of a new assay for predicting grilse in Atlantic salmon

A previous ACRDP project found an association between levels of Insulin-like Growth Factor -1 (IGF-1) and the level of grilsification. Unlike testosterone and vitellogenin, which also correlated with grilsification levels, IGF-1 data did not require knowledge of the sex of the fish for interpretation. Unfortunately, the assay for IGF-1 is a radioimmunoassay which, because it involves the use of radioactivity, is cumbersome and its potential benefits have not been transferred to industry.

For industry to benefit more fully from the initial research, it is necessary to develop an assay for IGF-1 levels which is as sensitive as the radioimmunoassay but easier and less expensive to perform. Industry will further benefit from research extending the scope to the wider application of the assay on the production and broodstock phases of the salmon aquaculture operation. In the future, industry may be able to modify the tools for applications in alternate species such as cod, haddock and halibut.

This project aims to:

- Develop and standardize a simple, cost effective assay for measurement of IGF-1 levels in Atlantic salmon.
- Study the levels of IGF-1 in production fish several months before harvest to assess the application of the IGF-1 assay for predicting grilse in Atlantic salmon before the on-set of early maturation.
- Study the levels of IGF-1 in broodstock fish in the months and years before grilse/salmon grading at 3 years of age to assess the application of the IGF-1 assay for predicting grilse in Atlantic salmon broodstock before onset of early maturation.
- Provide industry with inexpensive, rapid and reliable protocols for prediction of grilse in broodstock and production lots.

Research Team: Jake Elliott, Cooke Aquaculture Ltd (NB), Dr Rachael Ritchie, Research and Productivity Council, Molecular Biology Group (NB). Submitted by DFO (ACRDP). For Information contact Brian Glebe (E-mail: GlebeB@mar.dfo-mpo.gc.ca). Jul.'06-Mar.'07

DNA identification of chinook salmon the focus of BC research

Sophisticated selection programs such as those used for agricultural animals depend on the documentation of a pedigree for the strain under selection: the ability to identify an individual to its family provides both a more accurate determination of its genetic merit and a means to minimize inbreeding within the strain.

Maintenance of pedigrees for fish, with their large fecundity and requirement for aquatic habitat, poses novel problems for the breeder. Eggs and juveniles must be reared in separate family groups until marking or tagging can be carried out, which increases expense of the hatchery rearing phase, confounds environmental (rearing tank) and genetic influences on phenotypic traits, and stresses the fish by early marking.

Development of highly polymorphic codominant genetic markers (microsatellite loci) provides a method for estimation of relatedness among individuals without tags. Thus, molecular identification of fish to parents and/or family can be used to avoid the necessity of rearing full and half-sib family groups in separate tanks, greatly reducing rearing costs while simultaneously improving estimation of genetic merit in breeding programs. We will develop a most cost-effective suite of 6-10 loci that can be used for family assignment in domesticated BC chinook strains on an ongoing basis.

Research team: R. Withler, T. Rundle, B. Swift and R. Peterson. Submitted by DFO (ACRDP). For Information contact R. Withler (Email: withlerr@pac.dfo-mpo.gc.ca).

Sept.'06-Mar.'08

Identifying genetic markers for early maturation in farmed atlantic salmon

Early maturation of farmed fish, resulting in lost production and higher costs, is a major impediment in finfish aquaculture. Age-at-maturity in salmonids is a complex quantitative trait affected by numerous unidentified genes as well as environmental conditions. The improved growth and energy status experienced by farmed Atlantic salmon leads to a reduction in age at maturity relative to the wild populations from which they were derived. Atlantic salmon in BC are derived from the Mowi strain that originated in Norway and was imported into BC in the early 1980s. Based on the history of other domesticated Atlantic strains around the world, the loss of fish due to early maturation in BC could eventually reach 50% or higher.

In this project, we will test associations between early maturation and genetic markers (termed QTLs) developed by researchers at the University of Guelph to determine if these markers may be useful in identifying and selecting for fish with a genetic propensity for late maturation. The putative QTLs for age-at-maturity in Atlantic salmon have been identified in North American-origin Atlantic salmon in eastern Canada. In this study, we will determine if the QTLs identify major genes associated with age-at-maturity in an European-origin strain.

Research team: R. Withler (DFO), R. Danzmann (U. Guelph), M. Ferguson (U. Guelph), S. Fukui (Mainstream Canada), B. Swift (Tri-Gen Fish Improvements). Submitted by DFO (ACRDP). For Information contact R. Withler (Email: withlerr@pac.dfo-mpo.gc.ca).

Jan.'07-May'08

Study to examine emamectin residues in SLICE-treated salmon

SLICE® (active ingredient, emamectin benzoate) is used for the control of sea lice in farmed salmon. Sea lice are externally located, parasitic copepods. In commercial operations SLICE® is fed to fish, in the form of medicated feed, for 7 days. Emamectin is metabolized to inactive compounds by the fish and then excreted. Sea lice are considered a potential vector for the transmission of Infectious Salmon Anemia virus (ISAV). Elevated sea lice infestation is associated with increased stress, poor growth and increased susceptibility to opportunistic pathogens.

SLICE® was submitted for approval in the US and Canada in 1999; the approval process has not been completed. This drug can be sold to veterinarians on a case by case basis through Health Canada's Veterinary Drugs Directorate's (VDD's) Emergency Drug Release Program (EDR). VDD established a maximum residue limit (MRL) of 42 parts per billion (ppb).

This study will examine the emamectin residues in salmon muscle from salmon treated with SLICE® in conventional commercial operations (salmon cultured in sea cages) or in a controlled laboratory setting (indoor tanks). In each case, selected animals will be collected for up to 45 days following SLICE® treatment and tissues submitted for SLICE® content analysis.

Information from this project will assist Health Canada, CFIA and provincial government officials in their roles as regulators. Results from this project will also aid health and disease management decisions by aquaculture veterinarians, producers and Fisheries and Oceans personnel with regard to the use of SLICE® in commercial operations.

Research team: Phil Byrne (DFO), Province of New Brunswick, New Brunswick Salmon Growers Association. Submitted by DFO (ACRDP). For information contact Phil Byrne (Email: byrnep@dfo-mpo.gc.ca).

Jul.'06-Mar.'07

Researchers identify Atlantic salmon families using DNA methods

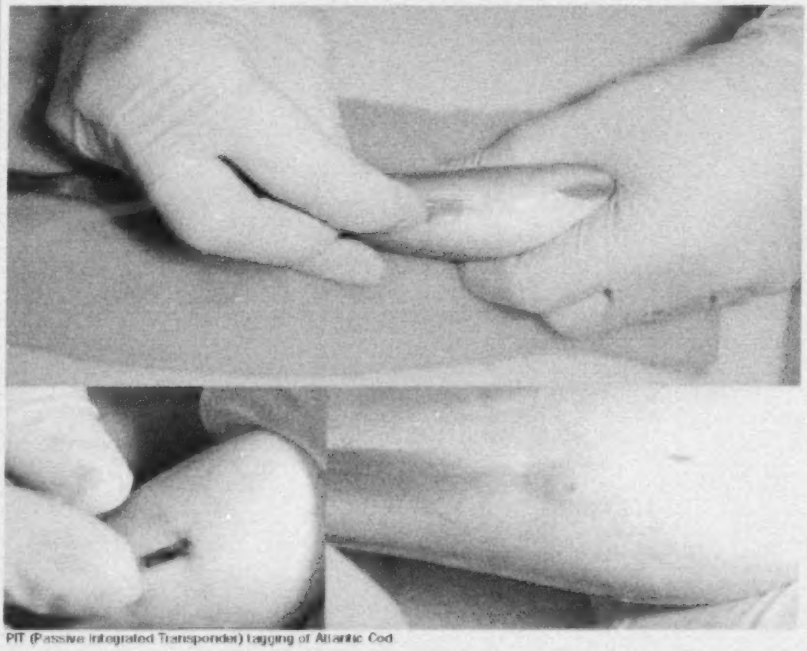
We will introduce the use of highly polymorphic microsatellite loci in BC Atlantic salmon strains for molecular identification of offspring to their parents in an ongoing selective breeding program (SBP). This will enable the communal rearing of juveniles from 150 fullsib families, eliminating the "common environment" effect of tanks and the need for single family tanks in the hatchery.

Multi-locus DNA genotypes from all parents spawned in 2004 and from 6000 of their progeny sampled before transfer to saltwater will be used to identify the progeny to family (i.e. the correct pair of parents). The juveniles will be tagged at the time of tissue sampling for subsequent identification to family, allowing future data collection and spawning to be carried out with full pedigree knowledge. There are many polymorphic microsatellite loci available for use but the feasibility of implementing molecular identification of juveniles on an on-going basis depends on the cost of analysis. This in turn depends on the number of loci that need to be assayed for accurate family assignment. We will evaluate the polymorphism at 12 to 15 loci in the SBP and identify the most cost-effective suite of 6-10 loci that can be used for family assignment.

Researcher team: R. Withler, S. Fukui, B. Swift and R. Peterson. Submitted by DFO (ACRDP). For information contact R. Withler (Email: withlerr@pac.dfo-mpo.gc.ca).

Apr.'05-May'07

Clinical field trials focus on salmon and cod in Newfoundland



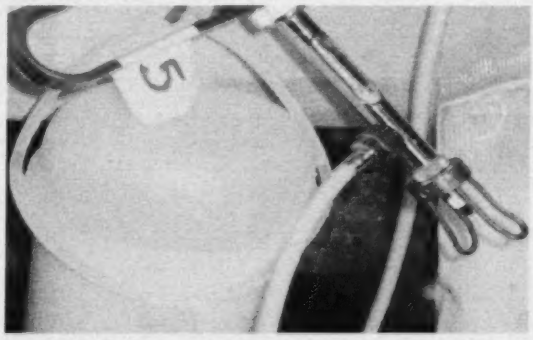
PIT (Passive Integrated Transponder) tagging of Atlantic Cod

The overall objective of this clinical trial is to provide the industry with evidence to critically evaluate the potential for adverse effects of adjuvants contained in different vaccines in Atlantic Cod and Atlantic Salmon. Furthermore, the role of smoltification in Atlantic salmon as well as timing of sea transfer in Atlantic Cod will be included in the study design. These objectives will be accomplished by using double-blind, randomized clinical trials under field conditions and evaluating the outcomes at the individual fish level using PIT (Passive Integrated Transponder) tags. The outcomes of interest here are growth, survival and carcass characteristics for individual fish. The fish are followed through to harvest and collection is expected to start in the next year.

Research team: Larry Hammell (UPEI AVC), Daryl Whelan (NLDFA), Nicole O'Brien (NLDFA). For information contact Larry Hammell (Email: lhammell@upei.ca). Submitted by ACOA-AIF

Sept.'04-Sept.'08

Scanning PIT tags to obtain baseline information in an Atlantic Salmon and vaccines used in salmon aquaculture



Genetic factors affecting susceptibility of salmon to Infectious Hematopoietic Necrosis virus

Infectious hematopoietic necrosis virus (IHNv) occurs naturally in the BC marine environment.

Part I of this study demonstrated that while farmed Atlantic salmon have little immunity to IHNv, Pacific salmon exhibit a species-specific range of resistance to the virus. Information on the molecular basis of IHNv resistance/susceptibility in salmon could be useful in the development of therapeutics and vaccines capable of reducing IHN outbreaks in Atlantic salmon.

The objective of this study was to identify genetic factors which influence the resistance of various salmon species to IHNv. Juvenile Atlantic, Chum, Coho, and Sockeye were infected with IHNv, and the activity of over 15,000 genes that regulate immune pathways was evaluated in each species.

The results of this study indicate that differences in IHNv susceptibility in salmon may not stem from the overall strength of the immune response. Instead, these differences in susceptibility may result from species-specific differences in the ability to prevent the virus from entering the host cells - and perhaps differences in which immune pathways the species uses to defend against the virus once it has entered.

Research team: Garth Traxler and Kristina Miller (DFO). For information contact Garth Traxler (Email: traxlerg@dfo-mpo.gc.ca). Submitted by BCARDC Aqua-E.

Three strains of Atlantics tested for triploid viability

Triploid salmon are sterile, and can be used to eliminate production losses associated with pre-harvest maturation as well as concerns with the feral spawning of escaped farmed fish. This project evaluates various aspects of the culture performance of triploid Atlantic salmon.

A comparison of three strains of triploid salmon (domesticated European, domesticated North American and wild North American) revealed significant strain effects on triploid post-smolt growth in a 12-week tank trial, with the wild triploids exhibiting the fastest growth rates. A long term parallel trial in commercial sea cages showed triploid wild strain salmon to grow just as well as diploids of the same strain, but both were inferior to diploid domesticated fish. These results point to the importance of selecting the best strains with which to evaluate triploid performance.

Experiments evaluating dietary energy and phosphorus utilization by triploid salmon are currently in progress. Pilot studies with triploid brook trout suggest that they do not perform equally to diploids when fed similar diets and therefore triploids may have different dietary requirements.

Research team: Tillmann Benfey (UNB), Santosh Lall (NRC IMB), Brian Glebe (DFO SABS), Charles Sacobie (UNB), Heather Mouland (UNB). For information contact Tillman Benfey (Email: benfey@unb.ca). Submitted by NSERC.

Sept.'03-Mar.'07

MSc candidate Heather Mouland measuring a triploid Atlantic salmon.

PhD candidate Charles Sacobie holding a triploid brook trout.

Aims Aquaculture Research Station – Canola oil – Experimental production.

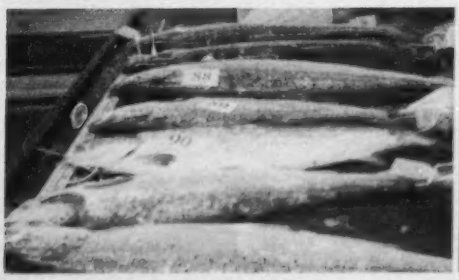
Incorporating vegetable oils in salmonid feed reduces contaminants and lowers production costs

The research project aims to develop nutritional strategies for minimizing potential contamination of salmonids by persistent organic pollutants (POPs) and heavy metals. Since these pollutants are fat soluble, efforts have been directed at replacing fish oil (the main source of contaminants) with alternative fat sources in order to minimize bioaccumulation of these contaminants in tissues.

Different vegetable oils have been tested in the feed, namely soy oil, canola oil and canola oil supplemented with long-chain polyunsaturated fatty acids (LCPUFAs) from marine sources, combined with varying protein to fat ratios capable of supporting growth during the phase when the bulk of body fat is accumulated. A short finishing period completed the study in order to restore the levels of LCPUFAs beneficial to humans. Assimilation of the new fat sources was evaluated through digestibility studies on rainbow trout in freshwater. Analyses of growth, finishing and digestibility are under way. An organoleptic study, based on sensory properties of a product, involving taste, colour, odour and feel, demonstrated that vegetable oils do not influence fish palatability for consumers. Finally, a brief economic study is being conducted to determine the industrial costs of using vegetable oil, generally less expensive and more readily available than fish oil.

Research Team: C.W. Vanderberg, A. Bélanger-Lamoute, J. Bailey, A. Desgenais, and É. Proulx (Laval U.); P. Ayotte, Y. Chouinard, É. Dewailly, A. Leblanc, and J.-P.Weber (Institut National de Santé Publique du Québec - INSPQ); D. Bureau (U. Guelph). Report submitted by AquaNet. For information contact Grant Vanderberg (Email: Grant.Vandenberg@san.ulaval.ca).

Aug.'05-Apr.'06



A faster diagnosis for Infectious Hematopoietic Necrosis

Infectious Hematopoietic Necrosis (IHN) is a viral disease capable of causing high mortality rates among juvenile farmed Atlantic salmon. The clinical signs of IHN are similar to several other diseases of Atlantic salmon. Laboratory testing is therefore required to confirm IHN. Currently, virus isolation (VI) via cell culture is recognized as the most effective method to detect the IHN virus (IHNv). However, VI requires an average of 15.7 days to complete the laboratory diagnosis. This time lapse contributes significantly to the spread of the disease.

Initial laboratory testing has suggested that use of the reverse transcriptase polymerase chain reaction (RT-PCR) assay could reduce the time required for diagnosis of IHN to 48 hours from the time of sample collection. The objective of this study was to evaluate RT-PCR using samples collected in the field to determine its reliability as a more rapid diagnostic tool for detecting IHNv in farmed salmon populations.

Fish from 3 farm sites were tested for IHNv and the reliability of RT-PCR for IHNv detection, its performance was compared to the VI test. The performance of RT-PCR on fresh or frozen samples was equivalent to that of VI. Given the short time from IHNv exposure to onset of clinical signs and mortality, the shorter diagnosis time achieved via RT-PCR will permit earlier management changes that may reduce spread of disease.

Research team: Larry Hammell, Sonja Saksida, Grace Karreman, Joanne Constantine, John Robinson, Garth Traxler with contributions from Ian Dohoo and Henrik Stryhn. Submitted by UPEI, Centre for Aquatic Health Sciences.
For information contact Larry Hammell (Email: lhammell@upei.ca)

BC researchers investigate effect of plant-derived oils on chinook salmon

The objective of this project is to replace in whole or in part marine finfish based oils in salmon diets with plant-derived oils, which are much less expensive, and address concerns of contaminants. The research focuses on ensuring that these alternative oils improve, or at least do not harm, the health, growth and performance of fish. Previous research indicates that a diet balanced in fish and plant derived oils actually enhances performance. This project examines the effects of canola oil on the performance of several strains of juvenile Chinook salmon, by feeding fish several diets with varying proportions of canola and anchovy oil, and monitoring growth, health, ion regulatory development, seawater tolerance and swimming performance.

In addition to filling knowledge gaps about the effects of alternate dietary lipids for salmon aquaculture, the research is providing valuable information for husbandry practices of Chinook salmon, a fish species that is prevalent throughout British Columbia. Reared in hatcheries as part of stock enhancement programs, an improved alternate diet is expected to increase the health and immune system of the juveniles and their survival in the wild.

Research team: Colin Brauner and Patricia Schulte (UBC), Robert Devlin and David Higgs (DFO). Report submitted by AquaNet. For information contact Colin Brauner (Email: brauner@zoology.ubc.ca).

Researchers identify molecular markers of efficient immune system in Atlantic salmon

Researchers investigated whether different families from the Atlantic Salmon Broodstock Program differed in their susceptibility to two pathogens. This research led to the identification of genetic markers and physiological indicators associated with disease resistance, and built the foundation for Marker Assisted Selection (MAS) in Atlantic salmon broodstock.

Associated gene mapping efforts conducted in collaboration with this research team localized a large number of anonymous genetic markers onto the Atlantic salmon genetic map. This genetic map, and the targeted gene mapping of specific stress tolerance, disease resistance, and growth related genes in Atlantic salmon, Arctic charr, and rainbow trout, provided a solid basis for the identification of quantitative trait locus regions associated with ISAv resistance in Atlantic salmon. Knowing what regions of the genome conferred resistance or susceptibility to ISAv in Atlantic salmon allowed the integration of this information into the selective breeding program for Atlantic salmon in New Brunswick and increased the rate of genetic improvement (i.e. increase ISAv resistance) after the whole broodstock has been genotyped.

Research Team: Roy G. Danzmann, Patrick T.K. Woo, and Moira M. Ferguson (U. Guelph), Brian D. Glebe (U. Guelph), Don Ramsay (UPEI-AVC), George K. Iwama (NRC-IMB). Project submitted by AquaNet.
For information contact Roy Danzmann (Email: rdanzmann@uoguelph.ca).

Mar '03-Mar '06

Evaluating current and new diagnostic tests for Infectious Salmon Anemia Virus - Phase 2

Infectious Salmon Anemia (ISA) is a viral disease that has caused major problems for the Canadian and the international salmon aquaculture sector. There are number of diagnostic tests available to identify infected fish, yet there had been no systematic evaluation of the diagnostic tests available and multiple tests often gave contradictory and confusing results.

To combat this, this project carried out a thorough, structured evaluation of all tests in common use and their ability to correctly identify infected fish (i.e. sensitivity of the test) and non-infected fish (i.e. specificity of the test). Six research institutions participated, with four collectively representing all of the fish health diagnostic laboratories in Eastern Canada.

The research designed superior disease control programs and initial results contributed to a re-evaluation of the disease surveillance program in New Brunswick and increased efforts to standardize tests for different diseases in salmonids. At an industry-wide ISA workshop in 2003, the results of this work were described as the most important research contribution for the industry. Results led to the development of a program of PCR (polymerase chain reaction) standardization by two labs in Canada and one in the USA. A follow-up meeting with federal, provincial and USA government institutions in 2003, led to a revision of control policies and a review of future directions.

Research team: Ian Dohoo, Larry Hammell, and Henrik Stryhn (UPEI - AVC).
Report submitted by AquaNet. For information contact Ian Dohoo (Email: dohoo@upei.ca.)

Research aims to optimize fish welfare during live-haul

Optimizing fish welfare during high density transports is essential from both moral and economic standpoints. In partnership with Batchelor Bay Management, Stolt Sea Farms, and Marine Harvest, experiments were carried out onboard the *Sterling Carrier* operating on the west coast of British Columbia. It is a state-of-the art live-haul vessel capable of carrying in excess of 200,000 pounds of fish per trip.

The team monitored fish behaviour and physiological parameters during the commercial live haul of adult and juvenile Atlantic salmon. Preliminary analysis of water quality and plasma constituents of smolts supports previous studies that transport by a live-haul vessel allows the fish to recover rapidly from the stress accumulated during closed transport by truck from the hatchery to the *Sterling Carrier*. Underwater video footage is being analyzed to detect any correlations between behavioural responses and physiological measures of stress.

Tanker truck unloading smolts into the *Sterling Carrier*.

The *Sterling Carrier* unloading production fish into holding pens at processing plant.

The measurement of bulk oxygen uptake rates during the transport of adult fish was used to non-lethally assess the overall stress level of fish in the live holds. Changes in oxygen uptake rates would reflect elevated metabolic rate of the fish if they are stressed during the transport procedure. Results showed a significant recovery within two hours of an initial loading stress, and indicated low stress levels were maintained for the remainder of the transport.

Research team: A. P. Farrell, S. Tang, M. Nomura, C. Brauner and N. von Keyserlingk (UBC), C. Wood (McMaster U.), K. Sloman (Plymouth U., UK). Report submitted by AquaNet. For information contact Tony Farrell (farrell@interchange.ubc.ca).

Jan. 05 - Sept.07

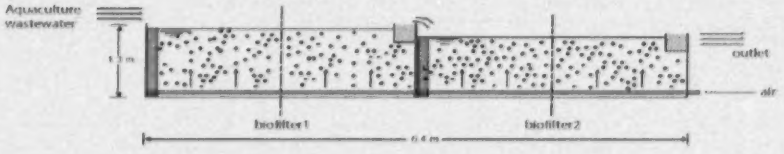
Vaccines and therapeutic assessments undergo field trials on East Coast

The effectiveness of therapies or health management techniques in salmon farming are influenced by husbandry, environmental, and other site-specific factors that are not easily identified or controlled in field trials, particularly when utilizing production sites for the trials. This study addresses the need for clinical field trials to critically assess the use of vaccines and chemotherapeutants in aquaculture. The objective of the clinical trial system is to provide the industry with highly credible evidence of the effectiveness of selected vaccines using randomized, double-blind clinical trials under field conditions, as well as individual growth, survival and efficiency as outcomes at the individual fish level.

A rigorous vaccine trial is being carried out to generate evidence of the impact the infectious salmon anemia virus (ISA) would have on a vaccinated population. Comparisons were made between vaccine groups to determine their effect on growth and survival. The natural influences of environment, husbandry, and host characteristics unique to the study sites allow for the evaluation of vaccines under different production situations.

This knowledge about vaccine effectiveness will enable regulators and industry to appreciate how changes in control policies may affect the financial imparts of ISA as well as provide a model for future study populations to be established for comparison of survival and growth in other regions or under new conditions such as new diseases.

Research team: Larry Hammell, Henrik Stryhn, Ian Dohoo (UPEI AVC). Report submitted by AquaNet. For information contact Larry Hammell (Email: lhammell@upei.ca). Nov. 04 - Aug. 07



Researchers study innovative recirc systems

The nitrification, degassing and oxygenation characteristics of the horizontal moving bed biofilter were investigated in a 6.2m long x 3m wide x 1.3 m deep unit in operation at a commercial salmon smolt hatchery. Buoyant plastic rings were used as the support media for the nitrifying biofilm and rising air bubbles kept the two cells of the biofilter well mixed. The air bubbles also maintained the water satured in oxygen and provided significant removal of carbon dioxide. By combining nitrification, degassing and oxygenation in one low-head unit, the horizontal moving-bed biofilter offers new design opportunities for reducing the pumping cost and the number of unit operations of recirculating aquaculture farms.

The hydrodynamic characteristics of multi drain fish rearing tanks were also investigated using 1.5m and 5m tanks. The rotational velocity in these tanks generates a secondary radial flow along the floor that carries settled particles to the central drain. The shape of the tangential velocity profile determines the strength of the secondary flow and therefore whether the tank is self cleaning. It is shown that the proposed triple-drain tank design provides greater flexibility than the conventional double drain designs for controlling tank hydrodynamics.

Research team: Michel F. Couturier (UNB). For information contact Michel Couturier (Email: cout@unb.ca). Submitted by NB DAFA.

Sept.'04-Mar.'06.

Feeding trials aim to reduce fish farm waste at the source

The reduction of solid, nitrogen (N), and phosphorus (P) wastes from aquaculture is key to ensuring the long term sustainability of the industry in Canada. Most wastes are from biological and dietary origins, so this project focused on waste reduction strategies at the source, through genetic improvements and by altering the feeds and feeding regimens.

Investigators and industry partners from Canada and other countries are collaborating on this project, bringing complimentary strengths in nutrition, genetics, physiology, growth modeling and environmental impact assessment. Feeding trials were carried out to examine the effects of diet composition, fish species and life stage on feed utilization and waste outputs. A nutrient flow growth model was adapted for salmonids, and an environmental decision-support system was developed for cage culture in freshwater. A model was constructed to predict solid and soluble P wastes. BOD impacts from various feed formulations were quantified to help calculate hypolimnetic impacts of aquaculture operations, and stable isotope analysis was used to track fecal dispersion. The research team is also involved in developing bioenergetics models to predict waste outputs of an experimental cage farm operated by DFO researchers in the Experimental Lakes site in Northern Manitoba.

The research findings will help Canadian feed manufacturers improve feed formulae and production models, and will assist regulators in establishing guidelines to both manage and mitigate the environmental impact of fish culture operations.

Research team: Dorathique P. Bureau, Muriel Mambrini, C.F.M. de Lange, Barbara Grisdale Helland, Richard D. Moccia, Staff, J. Helland, Stephen Bickett, Patricia Wright. Submitted by AquaNet. For information contact Dominique P. Bureau (Email: dbureau@uoguelph.ca).

Apr.'03-Aug.'06

Trout farmer hand-feeding fish. Feeds and feeding systems can directly impact both the benthic and pelagic environments surrounding freshwater aquaculture sites.

Feed formulations were manipulated in an attempt to reduce fecal BOD.

Post Doc Gregor Reid is collecting water samples adjacent to a commercial farm site to monitor diel fluctuations in dissolved phosphorus levels.

Genomic approaches to aquatic animal disease management

As with any intensively cultured species, farmed fish are subject to infectious diseases. At the National Research Council of Canada, Institutes for Marine Biosciences (Halifax) and Biological Sciences (Ottawa), a team of researchers is working with academic and industrial partners to develop efficient new tools and technologies for fish health management.

The Genomic Approaches to Aquatic Animal Disease Management program is intensive genomics and proteomics research focused on the *Aeromonas salmonicida* and Atlantic salmon (*Salmo salar*) model system. Results of that research include a complete genome sequence of *A. salmonicida*, insight into the proteome of this bacterium, knockout strains and a whole bacterial genome DNA microarray. The team has also developed a salmon immune system-targeted cDNA microarray, and array-based snapshots of the host transcriptome in response to infection. The team is developing rationally targeted antigens and delivery systems for vaccine and investigating the role of aquaculture-related stressors on the efficacy of the targeted vaccines to ensure these vaccines will be of use in real-life situations.

The program involves 13 laboratories in the NRC Institutes, along with Dr. Rafael Garduno at Dalhousie University. The team uses a broad range of investigative techniques including: genome sequencing, microarray, advanced mass spectrometry, protein expression, proteomics, metabolomics, nuclear magnetic resonance imaging and bioinformatics, among others.

Research team: Laura Brown (IMB-NRC). Andrew Doxaman (IMB), John Nash (IBS), Laura Brown (IMB), Desmond Pinto (IMB), Roger Ebanks (IMB), Jianjun Li (IBS), Chanuwa Altman (IBS), Michael Reith (IMB), Jessica Boyd (IMB), Vanya Ewart (IMB), Kelly Soanes (IMB), Stewart Johnson (IMB), Neil Ross (IMB), John Walter (IMB), Evelyn Soo (IMB), Rafael Garduño (Dalhousie U.), Luis Afonso (IMB). Submitted by NRC IMB. For information contact Laura Brown (Email: Laura.brown@nrc-cnrc.gc.ca).

Apr.'05-Mar.'08

Genomics research in British Columbia

Genome British Columbia is currently supporting two projects with interest to the finfish aquaculture industry. These two projects are cGRASP and GRASP and both aim to further our understanding of finfish genetics.

The Genomics Research on Atlantic Salmon Project, or GRASP, is working towards providing genetic answers to questions around Atlantic salmon reproduction, growth and health. The project is melding new research with previous studies to create a genome map for Atlantic salmon and analyzing the genome itself to examine evolution rates. Measurements of gene expression are also being examined to further understand the interaction between salmon and several environmental variables.

The Consortium for Genomic Research on All Salmonids Project, or cGRASP, aims to expand the knowledge base of genomics for Atlantic salmon and rainbow trout and to develop such a resource for brook charr and rainbow smelt. Information gathered through this project will further responsible development of aquaculture protocols for all four of these species.

The knowledge provided by these two projects will help to ensure sustainability and success of finfish aquaculture in Canada.

Researchers: Ben F. Koop (UVic) and William S. Davidson (SFU). Submitted by Genome BC.

Websites: http://web.uvic.ca/cbr/grasp/ or www.genomebc.ca

Feasibility of Pacific Oyster and California Sea Cucumber Polyculture

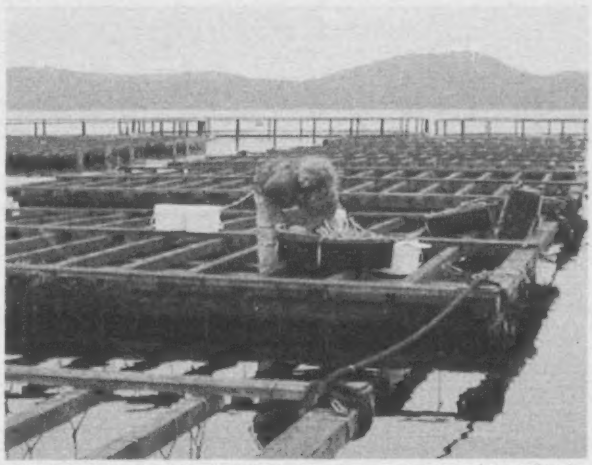
Growth and production of California sea cucumbers (*Parastichopus californicus*), co-cultured with suspended Pacific oysters (*Crassostrea gigas*), were investigated in a 12-month study conducted at two sites of deep-water, suspended oyster culture in British Columbia. Rates of oyster biodeposition (faeces and pseudofaeces), and the utilization of this particulate material as a food source by *P. californicus*, were also examined.

Peaks in sedimentation rates (93.6 g dry wt m^{-2} d^{-1}) through 8.5 m water depth were observed in April and July 2004. At the two study sites, maximum mean fluxes of total organic carbon in sediment traps at 8.5 m depth occurred in July 2004 and amounted to 3,123 and 4,150 mg dry wt C m^{-2} d^{-1}. Maximum mean fluxes of total nitrogen at the two sites were 633 and 441 mg dry wt N m^{-2} d^{-1} which occurred in July and November 2004, respectively. Mean C/N ratios of particulate material in the sediment trap samples collected at the two sites ranged between 5.93 and 8.39 and may be classified as being of high nutritional value.

Sea cucumbers grown in trays at both sites successfully utilized biodeposits from the cultured oysters and showed a mean weight increase of 42.9 g in approximately 12 months (average growth rates for both sites ranged from 0.061 to 0.158 g d^{-1}). Overall growth was affected by the absence of visceral organs and the cessation of feeding activity in the November 2004 sampling period. Mean values for organic content were significantly higher in the foregut of the sea cucumbers (233.0 mg g dry sediment^{-1}) than in the sediment (64.3 mg g dry sediment^{-1}) or in the hindgut (142.8 mg g dry sediment^{-1}), showing both active selection of organic material from the sediments and digestion/assimilation of these organics in the gut. Organic material deposited in the trays was assimilated by *P. californicus* with an average efficiency of 48.4%.

The successful utilization of the naturally-available biodeposits from the cultured oysters by sea cucumbers suggest the feasibility of developing a commercial-scale co-culture system that would both reduce the amount of organic deposition underneath shellfish farms and produce a secondary cash crop.

Research team: Chris Pearce (DFO), Debbie Paltzat (UBC), Penny Barnes (CSR), Scott McKinley (UBC). Submitted by DFO (ACRDP). For information contact Chris Pearce (E-mail: PearceC@pac.dfo-mpo.gc.ca).
Apr.'04 Jun'05



Debbie Paltzat examines trays in which oysters and sea cucumbers are being cultured together

Integrated multi-trophic aquaculture making headway in Canada

Integrated multi-trophic aquaculture (IMTA) holds great potential for improving the sustainability of aquaculture. Based on an age-old, common sense, farming practice, the wastes from one species become inputs for another: fed aquaculture (finfish) is combined with extractive inorganic aquaculture (seaweed) and extractive organic aquaculture (shellfish). With the support of AquaNet between 2001 and 2006, and now the Atlantic Innovation Fund (from the Atlantic Canada Opportunities Agency), an interdisciplinary team of scientists from the University of New Brunswick in Saint John, and the Department of Fisheries and Oceans in St. Andrews, is developing such a system at an industrial pilot scale by co-cultivating salmon (*Salmo salar*), kelp (*Laminaria saccharina* and *Alaria esculenta*) and blue mussel (*Mytilus edulis*) at several aquaculture sites in the Bay of Fundy. The industrial and government partners associated with the project are Cooke Aquaculture Inc., Acadian Seaplants Limited and the Canadian Food Inspection Agency.

After five years of research, our findings support the establishment of IMTA systems for environmental sustainability (bioremediation), economic diversification (from fish filets to bioactive compounds) and social acceptability (better management practices). Innovative kelp culture techniques have been developed and improved both in the laboratory and at the aquaculture sites. Increased growth rates of kelps (46%) and mussels (50%) cultured in proximity to fish farms, compared to reference sites, reflect the increase in food availability and energy.

Nutrient, biomass and oxygen levels are being monitored to estimate the bioremediation potential of an IMTA site. Salmonid solid and soluble nutrient loading is being modelled as the initial step towards the development of an overall flexible IMTA model. The extrapolation of a mass balance approach using bioenergetics is being juxtaposed with modern measures of ecosystem health such as exergy.

None of the therapeutants used in salmon aquaculture have been detected in kelps and mussels collected from the IMTA sites during the last five years; levels of heavy metals, arsenic, PCBs and pesticides have always been below regulatory limits. A taste test at market size conducted on site grown versus reference mussels showed no discernable difference. *Alexandrium fundyense*, the dinoflagellate responsible for producing paralytic shellfish poisoning (PSP) toxins, occurs annually in the Bay of Fundy and mussels can accumulate these toxins above regulatory limits in the summer/early fall. However, PSP toxin concentrations in mussels decreased readily as the blooms of *A. fundyense* diminished. Domoic acid, released by the diatom *Pseudo-nitzschia pseudodelicatissima*, was never above regulatory limits over the five years. All of these results indicate that, with the proper monitoring and depuration management, mussels and seaweeds from the IMTA operations can be safely harvested for human consumption.

A survey of aquaculture attitudes found that the public is more negative towards current monoculture practices and feels positive that IMTA would be successful. A focus group social study revealed that most participants felt that IMTA has the potential to reduce the environmental impacts of salmon farming, benefit community economies and employment opportunities, and improve the industry competitiveness and sustainability. All felt that seafood produced in IMTA systems would be safe to eat and 50% were willing to pay 10% more for these products if labelled as such.

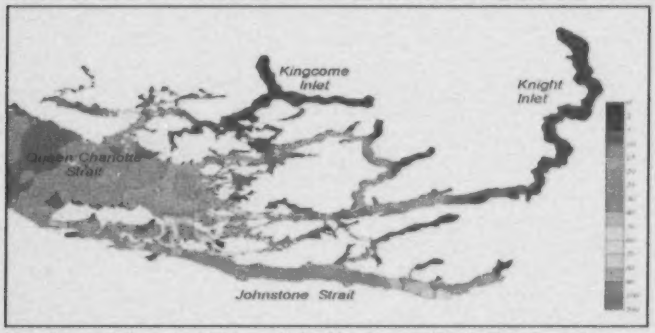
A bio-economic model is being developed in which net present value calculations are conducted. Variable data manipulation is incorporated and the model is stretched over 10 years to portray long term variability. Preliminary findings show that the addition of both seaweed and mussel farming to existing salmon farming is profitable and can help reduce risks.

We are now in the process of scaling up experimental systems and working with DFO, CFIA, EC and NBDAA on an appropriate food safety regulatory and policy framework that will allow the development of commercial scale IMTA operations.

Innovative kelp culture techniques have been developed and improved, increasing growth rates by 46% in proximity to farms.

Culturing mussels close to fish farms increases growth rates by 50% due to increased food and energy availability.

Research team: Thierry Chopin (UNB), Shawn Robinson (DFO), Fred Page, Neil Ridler, Manav Sawhney (UNB), Michael Szemerda (Cooke Aquaculture Inc.), John Sewuster (Acadian Seaplants Ltd.), Sharon Boyne-Travis (CFIA). For more information contact Thierry Chopin (Email: tchopin@unbsj.ca). Submitted by ACOA-AIF and AquaNet.
2001-2011



Map of the vertically-averaged tidal currents (cm/s) in the model domain of the Queen Charlotte Strait and Broughton region of British Columbia.

SEA LICE ON THE MOVE

Studying surface drift in the Broughton Archipelago

The circulation of waters in the Broughton region of BC has been the subject of a recently completed ACRDP project and a component of a new ACRDP project to investigate the life history of sea lice. Field programs and numerical circulation models have significantly increased the knowledge and understanding of the circulation of this complex region and identified key areas for further research. Scientists have used particle tracking software and numerical model currents to simulate the movement of pathogens, toxic algal blooms and planktonic larval stages of salmon louse from different source locations. These particle tracking simulations provide estimates of the transport pathways, distances traveled and concentration of particles in the model region.

In this project the researchers plan to conduct detailed measurements of near surface circulation at several farm sites and other areas of interest using GPS tracked surface drifters.

The drifter experiments will also be used to verify model representations of the mean surface circulation and to compare with our particle tracking simulations. Furthermore, the researchers plan to extend the program of current meter observations in order to have observations of current movements that are coincident with the drifter experiments.

Research team: Dario Stucchi, Mike Foreman and Clare Backman. Information: Dario Stucchi (StucchiD@pac.dfo-mpo.gc.ca). Submitted by DFO (ACRDP) (ACRDP) and Marine Harvest Canada

Estimating the risk

The objectives of this project are to assess the effect of sea lice infestation levels on the swimming and reproductive ability of salmonid species native to British Columbia. It will also identify the effect and source of sea lice on wild migrating fish stocks, and construct a risk assessment model to help predict the risk of infestation from sea lice in areas with and without farming activity.

Using innovative telemetry technology, the project tracked migratory paths of salmon to determine the risk of infestation during their outmigration. The project has determined the effects of various infestation levels on fish physiology and verified stable isotope ratios as a reliable tool to trace the origin and migration routes of sea lice found on wild and farmed salmon. The data can be used to calculate the number and location of farms to site in a specific area to minimise the risk of transmission of sea lice to the passing wild salmon. A risk assessment model for Atlantic salmon is in progress and will be published.

The provincial government of British Columbia provided funding for an international conference on sea lice biology and control that identified research priorities and led to new collaborative research projects. The project results will have considerable effect on public policy and help guide coastal management and have created a high level of interest at the provincial and federal government levels.

Research Team: R. Scott McKinley, Birgit Finstad, John Burke.
Submitted by AquaNet. For information contact Scott McKinley (Email: mckin@interchange.ubc.ca) May'03-Mar.'05

Research could lead to sea lice vaccine

Sea lice are parasitic copepods that live on the external surfaces of their hosts. One species, the salmon louse, *Lepeophtheirus salmonis* is an economically important parasite of both wild and farmed salmonids. On most host species there is limited host tissue response to attachment and feeding of this species. This observation has led to the view that *L. salmonis*, like other arthropod parasites (e.g. ticks), secretes compounds that modulate host immune responses and ensure their survival on hosts.

We have partially identified and characterized secretory compounds of *L. salmonis*. Similar to ticks, *L. salmonis* produces a complex mixture of both protein and non-protein components such as prostaglandin E_2 (PGE_2), which is well documented to have major effects on immune function in other vertebrates. These compounds have been shown to reduce the expression of Atlantic salmon genes involved in inflammation using Real-Time PCR. Inflammation has been identified as being a very important mechanism with respect to the rapid loss of *L. salmonis* from coho salmon, a species on which *L. salmonis* fails to survive.

This study provides the first hard evidence for immunomodulation by a parasitic copepod. These data are not only an important foundation for future studies of parasitic copepod host-parasite interactions but have led to the formulation and testing of a sea lice vaccine in collaboration with Microtek International. We are proceeding with further vaccine trials within the laboratory prior to testing in a cage culture system.

Research team: Dr. Mark Fast, Dr. Stewart Johnson, Dr. Neil Ross.
Submitted by Institute for Marine Biosciences, NRC, Halifax, Nova Scotia.
For information email: mark.fast@nrc-cnrc.gc.ca Sept.'04-Mar.'07.

Incorporating natural cycles of sea lice production into management for sustainable aquaculture

The Broughton region is an important area for wild salmon and for salmon farming. Concern over pink salmon in the Broughton region was raised when the escapement in 2002 declined following a record high escapement in 2000. This decline in escapement was associated with sea lice on the juvenile salmon. It was suggested that an increase in sea lice occurred as a result of salmon farming. Our studies examined the wild production of pink salmon. The Glendale spawning channel facility was built in 1989 and has had a major influence on pink salmon production. In recent years, the escapement of adult pink salmon to the Glendale represents over 70% of all escapement to this region. The marine survival of pink salmon to the Broughton region from year to year is variable. There was good survival in 2003/2004, average survival in 2004/05 and lower survival in 2005/06. The decrease in survival and resulting escapement in 2005/06 is not restricted to this region but is being observed throughout British Columbia.

Our study also documented the abundance of sea lice on adult salmon and on fish farms in the study region to improve our understanding of the dynamics of sea lice. Virtually 100% of the adult Pacific salmon returning to the coastal waters were highly infected with sea lice. We suggest that this transport of sea lice from the high seas to the coastal waters is an important part of the sea lice life history strategy. A study examining the production of sea lice on a fish farm located at the junction of Knight Inlet and Tribune Channel is currently being completed. This work will improve our understanding of the dynamics and timing of sea lice production in the coastal region.

Research team: Richard Beamish, (DFO, PBS), Chrys Neville, Ruston Sweeting, Grace Karreman, Sonja Saksida.
Submitted by DFO (ACRDP). For information contact Richard Beamish (Email: BeamishR@pac.dfo-mpo.gc.ca).

May'05-Jun'07

Examination and enumeration of sea lice on troll caught Pacific salmon in Queen Charlotte Strait.

Examination and enumeration of sea lice on hook and line caught Atlantic salmon on salmon net pen site.

Are wild Pacific salmon susceptible to sea lice infection?

Researchers test the hypotheses

There is a concern that farmed Atlantic salmon affects the health of wild Pacific salmon by acting as reservoirs for the salmon louse, *Lepeophtheirus salmonis*. However, the susceptibility of juvenile Pacific salmon to the parasite is poorly understood. Researchers tested the hypotheses that juvenile pink and chum salmon are equally susceptible to *L. salmonis* and, that a nutrient-deficient diet is associated with more severe *L. salmonis* infestations.

They found that the prevalence and abundance of *L. salmonis* following laboratory exposures to 243 or 735 copepodids per fish was significantly higher on chum compared to pink salmon. The weight and hematocrit of exposed chum salmon was significantly less than unexposed chum salmon. Neither weight nor hematocrit of pink salmon was affected by sea louse exposure. No mortality was observed among either species of salmon and most lice were lost by 28 days.

Species differences in cortisol response, expression of proinflammatory genes and histological inflammatory lesions, were linked temporally to parasite elimination. In addition, a reduced diet significantly affected the expression of immune genes in the juvenile salmon but parasite abundance was not affected. There is a relatively enhanced innate resistance to *L. salmonis* in healthy, juvenile pink salmon.

Research team: Simon Jones, Stewart Johnson, Mark Fast, David Groman. Contact: Simon Jones (jonesst@pac.dfo-mpo.gc.ca). DFO (ACDRP)

Mar.'06-Mar.'07

Testing sea lice loads

The objective of the study was to quantify the relative susceptibility of species of juvenile salmon to infection by salmon lice in laboratory and marine environments.

In 2003, laboratory tanks containing juvenile pink, chum and chinook salmon were artificially infected with a standardized level of infective salmon lice (low exposure level). A second tank of chinooks (high exposure level) was infected with twice the standardized level of lice. The number of salmon lice/fish and mortalities were recorded daily for 30 days following infection. The following year (2004) laboratory tanks containing juvenile pink and chum salmon were again artificially infected with lice at the 'high' and 'low' exposure levels.

The juvenile chums (2003 batch) had significantly lower levels of lice/fish than pinks or Chinooks and levels of lice/fish on pinks and chinooks did not differ significantly. The 'high exposure' group of chinooks had significantly higher lice levels than any of the 'low exposure' groups. Each group of infected fish had a mortality rate higher than groups of uninfected fish. In addition, the 'high exposure' chinooks had a 41% higher mortality rate than 'low exposure' chinooks.

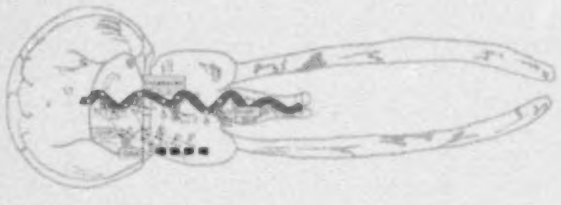
The 'low exposure' chum salmon had an average of 44 lice/fish while the 'high exposure' chum infection level was 87 lice/fish. In contrast, the average infection level for the 'low exposure' pink salmon was 0.05 lice/fish – while the 'high exposure' pink infection level was 1.52 lice/fish. These results indicate that: (i) pink and chum salmon differ in their ability to resist infection by salmon lice; (ii) higher lice levels in the marine environment may lead to higher levels of infection.

A. Mazumder. Submitted by AquaNet. For additional information get in touch with Asit Mazumder (mazumder@uvic.ca). Submitted by ACRDP/AQE Fund.

Researching resistance

This research is aimed at developing strategies to identify and monitor sea lice sensitivity to emamectin benzoate (SLICE®). Due to the limited chemotherapeutic options available, there is a continued reliance on emamectin benzoate for the control of sea lice on farmed Atlantic salmon, making resistance development a major concern. Two major mechanisms of avermectin resistance in arthropods and nematodes, P-glycoproteins (P-GP) and avermectin receptors (glutamate- and GABA-gated chloride channels) have been identified in sea lice.

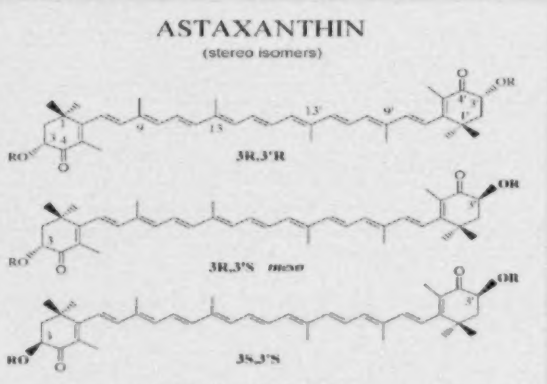
We have examined the expression of P-GP in sea lice and its potential role in resistance development using poly- and monoclonal antibodies in western blots and immunohistochemistry and have identified P-GP in sea lice intestinal epidermis.

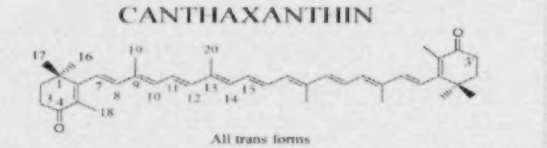


This is the first evidence of a multidrug efflux pump in sea lice which will allow detection of upregulation, should resistance to emamectin benzoate develop. P-GP expression in sea lice is being examined using real-time RT-PCR which will be an excellent tool for measurement of P-GP upregulation. We have also identified the genes for the avermectin target sites, glu- and GABA gated chloride channels.

Experiments are now underway to express glu- and GABA receptors from the genes identified and compare the binding characteristics to those *in situ*. The development of both molecular and biochemical tools will aid in the early detection of resistance allowing veterinarians and fish farm personnel to make decisions on alternative treatment measures.

Research team John Banks and Larry Hammell. Submitted by AquaNet. Apr.'02-Dec.'06.





Tracing sea lice in the Broughton

Can carotenoid pigments help determine the origin of sea lice?

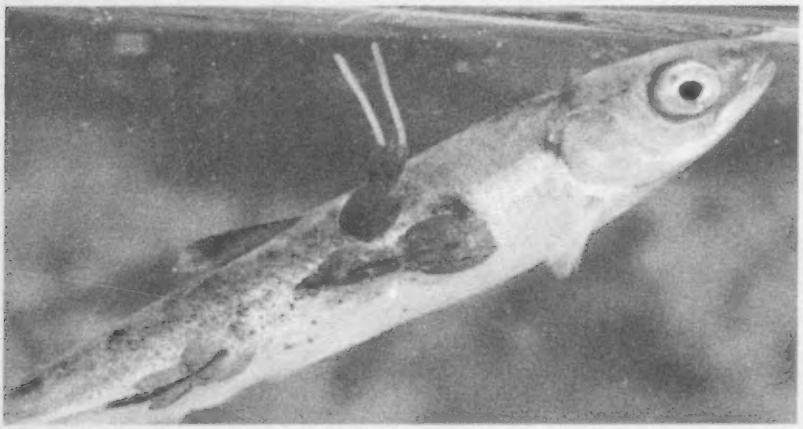
The objective of this study was to assess the potential of carotenoid pigments for determining the origin of salmon lice infecting pink salmon smolts in the Broughton Archipelago. To do this carotenoid pigments were extracted from salmon lice from wild and farmed salmon in the Broughton Archipelago – as well as tissue samples from both wild and farmed salmon.

The study showed that the carotenoid pigment composition of salmon feeding on wild prey differed from that of salmon consuming food containing synthetic pigments. This confirms that pigment composition could be used to differentiate wild and farmed salmon.

However, salmon lice collected from wild and farmed salmon could not be differentiated on the basis of their carotenoid pigment composition. This finding suggests that the origin of salmon lice infecting wild juvenile salmon in the Broughton Archipelago may not be determined unequivocally via the characterization of carotenoid pigments.

While characterization of pigment composition was ineffective in differentiating salmon lice from farmed and wild salmon, chemical tracers may still provide a useful approach in determining the source of the lice infecting juvenile salmon. Since large differences in fatty acid and stable isotope profiles have been observed in wild and cultured salmon, characterization of these profiles in lice may prove valuable in identifying the source of salmon lice infestations.

Research team: Marc Trudel, J.N.C. (Ian) Whyte, Simon Jones, Kang Pee Ang. Submitted by BCARDC. For information contact Mark Trudel (E-mail: trudelm@pac.dfo-mpo.gc.ca)



Salmon/sea lice interactions

This study is about how salmon aquaculture changes the ecology of a native host-parasite system (sea lice and salmon) and how this challenges the conservation of wild Pacific salmon. The research is highly collaborative and involves a combination of field work, experimentation, and modeling. The first step has been understanding how aquaculture changes the natural transmission dynamics of the parasite. Because salmon are migratory, juvenile and adult salmon are spatially separated and this means that juvenile salmon experience a natural refuge from parasites in early marine life. Salmon farms may undermine this refuge by providing a reservoir for lice that exposes juvenile salmon in early marine life. This effect may have dramatic consequences on salmon survival - sea lice are widely considered benign on adult salmon, but when infecting juvenile salmon they are a severe pathogen. Only one or two lice are lethal and this may correspond to a 9-95% mortality in juvenile salmon populations due to parasite transmission from farm salmon. It still remains unknown if these dynamics place new limits on wild salmon populations as a whole. Circumstantial evidence suggests that affected wild salmon populations have declined, however, a thorough analysis has yet to be undertaken.

Research: Martin Krkosek. Funded in part by NSERC. Information: (http://www.math.ualberta.ca/~mkrkosek/)

North Coast sea lice research

This project was designed to examine the hypothesis that sea lice, especially *L. salmonis* are transmitted by returning adult salmon to migrant salmon juveniles about to enter the inshore coastal waters. It's intended to test whether *L. salmonis* levels increase as vectors become abundant in the juvenile migrant staging areas of coastal waters in northern BC.

Research team: Allen Gottesfeld, Bart Proctor, Dave Rolston, R.J. Beamish, Dave Peacock. Submitted by the Pacific Salmon Forum. For more information get in touch with Allen Gottesfeld (Gottesfeld@skeenafisheries.ca). Apr.'05-Apr.'07

Tallying pinks in the Broughton

This project estimates the abundance of juvenile pink and chum salmon in the Broughton in July 2006 in order to determine if the area around the salmon farms is a passageway for migrating juvenile salmon or a rearing area as well as a migration corridor. It will also determine the health of the juvenile salmon that reared in the Broughton area in July 2006.

Research team: R.J. Beamish, Chrys Neville, Ruston Sweeting, Grace Karreman. Submitted by the Pacific Salmon Forum. For information contact Richard Beamish (beamishr@pac.dfo-mpo.gc.ca). Jul. Nov.' 06

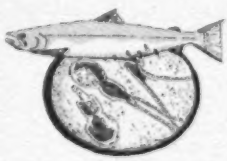
Do sticklebacks play a role?

This project will produce a literature review of the biology and ecology of the stickleback; provide preliminary data on their habitat use, on-host choice and host-switching behavior of *L. salmonis*.

Research team: Lawrence Dill; submitted by the Pacific Salmon Forum. For further information get in touch with Lawrence M. Dill (ldill@sfu.ca). Mar.'06-Mar.'07

Managing sea lice: does it work?

This proposal has three components: farm sea lice sampling, spatial sampling of juvenile pink and chum salmon for sea lice before and after they pass the treated farms and data analysis and modeling to detect and estimate transmission from farm salmon to wild salmon.



Research team: John Volpe, Martin Krkosek, Mark Lewis, Craig Orr. Submitted by the Pacific Salmon Forum. For additional information contact John Volpe (jpv@uvic.ca). Mar.-Jul.'06

Susceptibility compared

This project will build on ongoing research and seek answers to questions that are relevant to understanding the impacts of *L. salmonis* infections on juvenile pink and chum salmon. It will pose the following questions: how does the susceptibility compare with that of juvenile Atlantic salmon, what is the effect of prior exposure to *L. salmonis* on the establishment and outcome of subsequent infections, and are differences in susceptibility between species related to differences in how *L. salmonis* responds to the different host species?

Research team: Simon Jones, Stewart Johnson, Mark Fast, David Groman, Keng Pee Ang, Betram Svanvik. Submitted by the Pacific Salmon Forum. For additional information contact Simon Jones (jonesss@pac.dfo-mpo.gc.ca). Mar.'06-Mar.'07

Monitoring sea lice in Clayoquot Sound

This study will measure prevalence and intensity of sea lice over time and space in the Bedwell Sound and Tofino Inlet emigration routes in Clayoquot Sound. It will record data on growth patterns of sampled salmonids; record abundances of salmonids; and work with DFO and others to provide integrated understanding of results and to further develop cooperative sea lice monitoring programs between First Nations and industry.

Research team: Mike Jacobs, Don Hall, Darrell Campbell, Andrew Jackson, Spencer Evans, Randy Mercer. Submitted by the Pacific Salmon Forum. Information: (mjacobs@nuuchahnulth.org). Mar. Dec.'06

Sea lice potpourri

This project is intended to answer a number of questions: is there significant infection of sea lice on juvenile pink salmon in between Sargeaunt Pass and Glendale Creek (areas where there are no fish farms)? How and when and where do juvenile pink salmon from Glendale Creek first acquire sea lice? When and how does a fish farm become infected with sea lice and is there amplification of sea lice? Given that sticklebacks commonly occur in and around net pens, what role do they play, if any, in the connectivity of lice on farmed and wild salmon? What happens to sea lice on wild fish after SLICE treatments? And is there an over-winter stage of *L. salmonis* or *C. clemensi* that is missing from our current understandings of the life cycle?

Research team: R.J. Beamish, Chrys Neville, Ruston Sweeting, Simon Jones, R. Kabata, Bill Pennell, Grace Karreman, Dale Blackburn. Submitted by the Pacific Salmon Forum. For more information contact Richard Beamish (beamishr@pac.dfo-mpo.gc.ca). Apr.'06-Mar.'07

Pilot study to evaluate sea lice sampling procedures

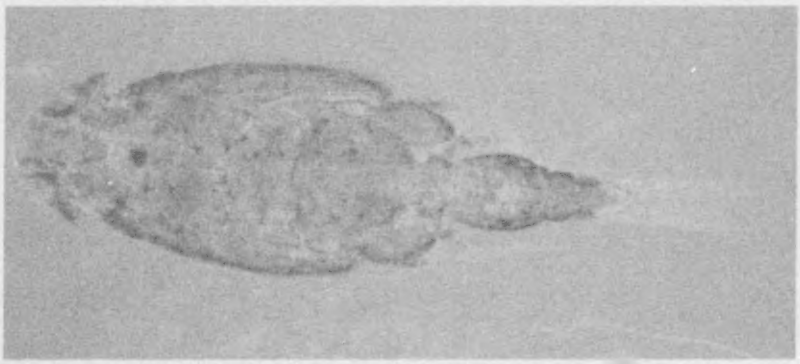
This project is expected to result in identification of particular locations in the survey region where sea lice larvae congregate in appreciable concentrations or are repeatedly found. It will also provide improved understanding of the vertical distribution of sea lice larvae; insight into preferred habitats or locations of planktonic sea lice larvae; identification of environmental factors associated with sea lice larvae and assessment of temporal distributions. Also being investigated is generic market analysis and evaluation of light traps as effective remote sampling devices for capturing planktonic sea lice larvae.

Research team: Dario Stucchi, Moira Galbraith, Martin Krkosek, I. Novales Flamarique, R. Mercer. Submitted by the Pacific Salmon Forum. For more information contact Dario Stucchi (stucchid@pac.dfo-mpo.gc.ca). Apr.'06-Mar.'07

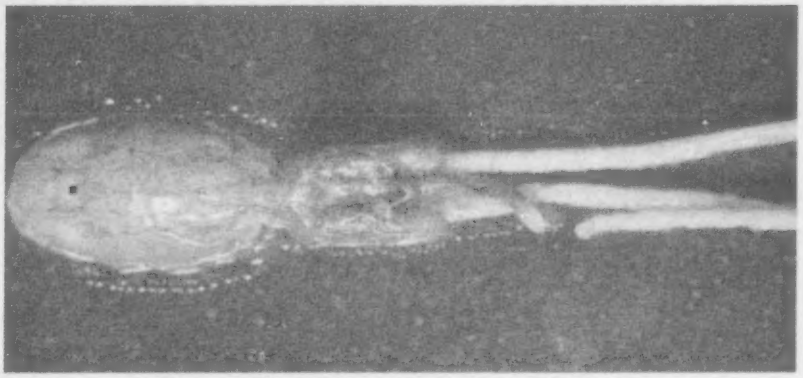
Researchers study impact of sea lice on coho and chinook salmon

These laboratory-based studies will provide data on the effects of sea lice infestation on the health of coho and chinook, the most severely declining of all Pacific salmon species. To date, it is not known just how many sea lice are detrimental to the health of migrating juvenile Pacific salmon. These data in conjunction with the results of the BCARDC project will provide a benchmark that can be used to decipher the data collected by DFO sea lice surveys that record infection intensity. This will enable the ascertainment of the risks posed by sea lice to wild juvenile salmon. Field studies will show the impacts of sea lice on specific wild salmon stocks deemed to be at risk by stakeholders in the Broughton.

Research team: Kevin Butterworth, Scott McKinley, Fiona Cubitt Bengt Finstad, Diane Morrison, Tony Farrell. Submitted by the Pacific Salmon Forum. For information contact Kevin Butterworth (kevingb@interchange.ubc.ca). Apr.'05-Mar.'07



Researchers use sea lice, like those shown here, to determine risks posed by lice on wild juv[illegible] salmon.



Does sea lice infestation increase predation risk?

SFU graduate student Paul Mages was awarded the Pacific Salmon Forum's first directed research grant for student research into wild/farmed fish interactions with a focus on disease and/or parasite transfer. His study is entitled, Early Marine Survival of Pink Salmon: Effects of Sea Lice on Predation Risk. One of the unanswered questions about the impact of sea lice on pink salmon is whether sea lice infestations increase the chances of very young pinks being killed by predators (most commonly, juvenile coho salmon). Mages is going to test whether young pinks, once they are infested, are more prone to be killed by juvenile coho, either because the infestation affects their swimming speed or because it causes them to take greater risks getting food, which in turn makes them more vulnerable to predators.

Research team: Paul Mages. Submitted by the Pacific Salmon Forum. Information: Paul Mages (pmages@sfu.ca).

Evaluating the enumerators

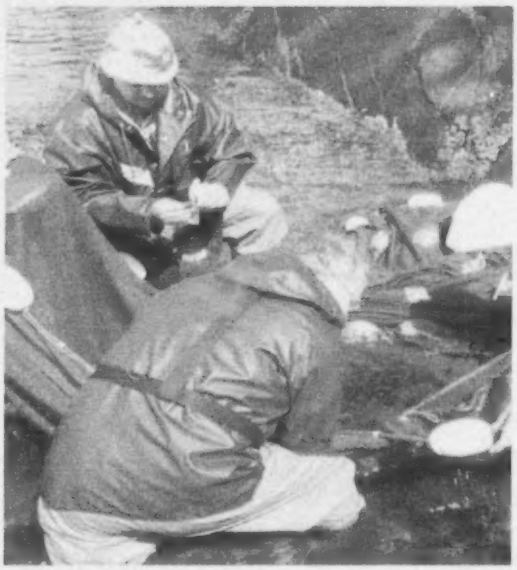
This study will evaluate the use of DIDSON sonar on the Glendale mainstem to enumerate returning pink salmon and to provide an in-season calibration to the over flight observations of pink salmon to that system.

Research team: Pieter Van Will, Dr. John Holmes, Dean Wyatt. Submitted by the Pacific Salmon Forum. Information: (vanwillp@pac.dfo-mpo.gc.ca). May'06-Feb.'07

Sea lice monitoring continued

Objectives of this study are to continue (and to harmonize) the annual monitoring of sea lice infection of juvenile pink and chum salmon in the Broughton and Knight Inlet; and to conduct more intensive sampling of juvenile pink and chum salmon in Tribune Channel and Knight Inlet to obtain additional information on the patterns of sea lice infection of wild salmon in these areas in 2006 and 2007.

Research team: Brent Hargreaves, Simon Jones, Alexandra Morton. Submitted by the Pacific Salmon Forum. For more information get in touch with Brent Hargreaves (hargreavesb@pac.dfo-mpo.gc.ca). Mar.'06-Nov.'06



Nova Scotia study aims to match shellfish stocking density to food availability

Low-cost monitoring devices under development

It's in no one's best interests to have shellfish operations depleting phytoplankton food sources in bays off the Canadian coast, but it can be an expensive proposition to buy all the highly sensitive monitoring equipment to assess the right amounts of biomass to match a particular area's natural resources.

"Optimization of yields depends on matching the stocking density of shellfish to the availability of food," said oceanography professor Dr. John Cullen, Chair of Environmental Observation Technology at Dalhousie University in Nova Scotia.

"Too many shellfish per acre will deplete the food resource and growth will be low; too few shellfish and harvests will be less than nature could support."

So doctoral student Diego Ibarra is working under Cullen on a research project to come up with cost effective measuring systems which will be sufficiently accurate to help growers keep a handle on the most suitable levels of biomass for their different sites.

Diego Ibarra deploys monitoring array.

According to Cullen, as lead investigator on the project, much of the work is being done by Ibarra, who has indicated an interest in coming up with appropriately inexpensive devices for the industry, based on more sophisticated devices generated by Cullen and others from previous oceanographic studies on the areas around shellfish farms.

Some of that work with larger, higher tech observation and monitoring systems is still continuing, in part to aid Ibarra in his research, said Cullen; and Dalhousie now has what Cullen refers to as "an ocean observatory" using a series of buoys in Ship Harbour, Nova Scotia.

The observatory consists of four buoys fitted with automated measuring devices to collect information on the oceanographic, meteorological and optical properties of the water, some of it being transmitted directly back to data banks at Dalhousie for storage and retrieval.

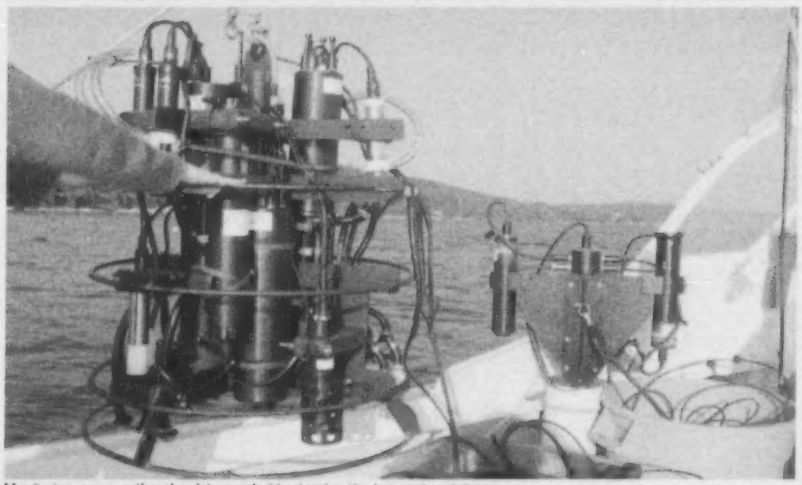
Cullen and Ibarra are particularly monitoring the clarity and colour of the upper few metres of the ocean in the bay directly around mussel rafts in the area.

Cullen said the work will allow researchers to make their own estimates of the concentrations of phytoplankton populations and of other water borne substances – such as sediment in the immediate vicinity of shellfish cages, which will also enable project personnel to calculate the uptake of the microscopic phytoplankton by shellfish at the operations.

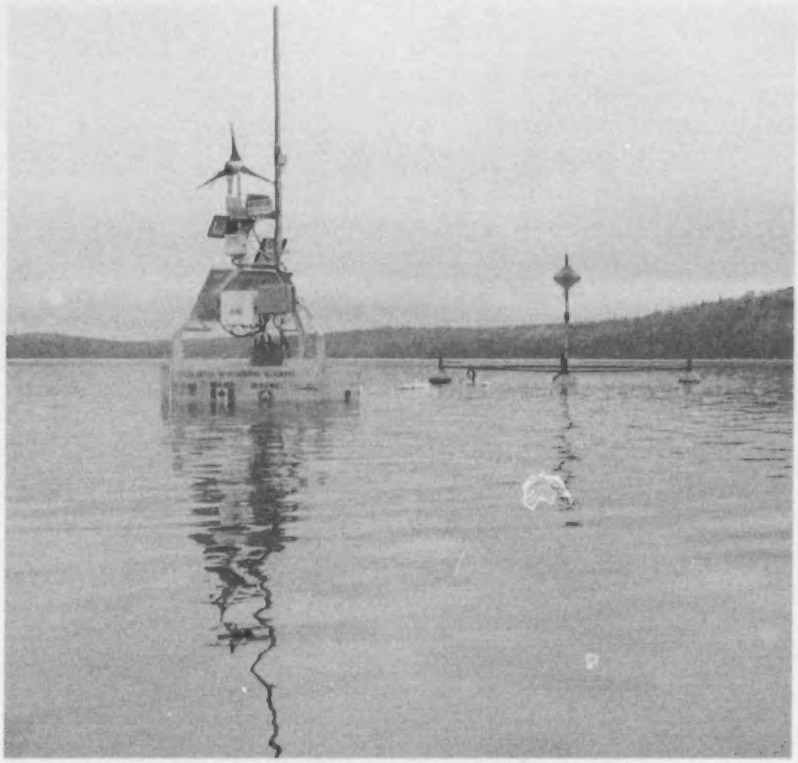
"It's basically a new, automated approach to obtain nearly continuous recording of the properties of the water," said Cullen, adding that water samples are also taken to ground truth the accuracy of their sensors and data.

"The instruments on the buoys give us very detailed measurements of the optical properties of the water, and we compare them with simultaneous findings from people going out and sampling the water," he said.

"We use these comparisons to come up with equations which will let others estimate the concentrations of materials in the water at their sites, using comparatively inexpensive light and clarity-monitoring instruments being developed by Ibarra," said Cullen.



Monitoring arrays gather the data needed to develop the low cost prototypes.



An "ocean observatory" has been created by using a series of buoys in Ship Harbour, Nova Scotia.

Cullen said that the much larger and more high tech instruments require comparatively large, moored buoys in the bay, but Ibarra has managed to devise prototypes for much smaller, less costly and less detailed instruments which can be hung at different depths from much smaller buoys.

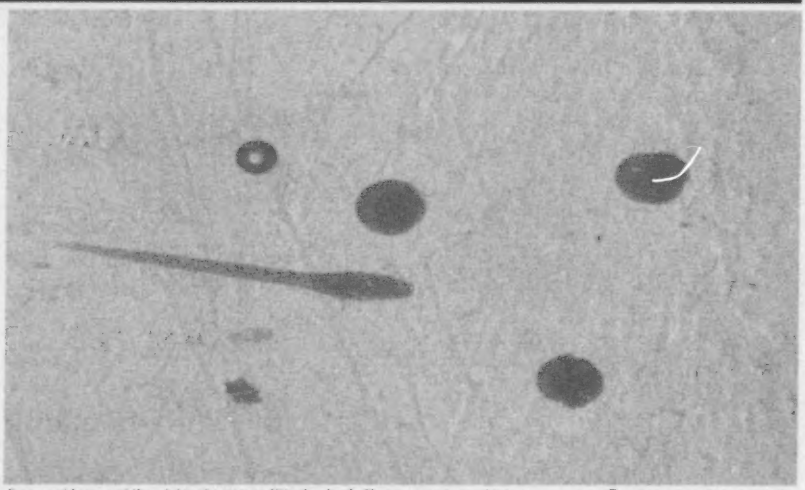
The two year research project, which springs from studies dating back to 2000 is being conducted with the help of AquaPrime and the Satlantic Inc instrumentation company. The study is due for completion next spring, but is to be extended to both British Columbia and Spain as Ibarra works towards his doctoral degree in about two years' time.

Research team: John Cullen, Diego Ibarra and Penny Barnes, with partner Satlantic, Inc. Contact: John Cullen (John.Cullen@Dal.CA). Submitted by AquaNet Jan. 05 Mar. 08

Controlling invasive tunicates in PEI

Several invasive tunicates have been introduced into Prince Edward Island waters during the last decade. These pests could have a devastating effect on the sustainability of the entire PEI mussel industry. Propagation of aquatic invasive species (AIS) generated by processing plants has not been well documented. The main risk attributed to processing is the movement of product (including hitchhikers) to the facility and subsequent release into receiving waters through effluent. There is an urgent need to understand the risk of dispersal of AIS through processing facilities to avoid any further spread. This study evaluates the risk of spreading tunicates associated with husbandry practices and environmental conditions within processing plants. Propagation pressure may vary considerably in relation to environmental, husbandry and infestation characteristics within these plants. The main focus of this research is to identifying processing stages that present a high risk of introduction and develop control strategies to minimize the potential for gamete and larvae release.

Research team: Daniel Bourque, Angeline LeBlanc, Dr. Gilles Miron, Thomas Landry. Submitted by DFO (ACRDP). For information contact Daniel Bourque (Email: bourqued@dfo-mpo.gc.ca) Jun.'05 Mar.'08



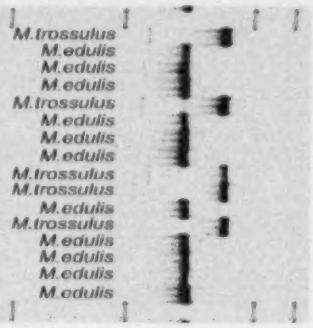
Eggs and larvae of the clubbed tunicate (*Styela clava*). These are released into processing effluents and could potentially be introduced into non-infested waters.

Identifying Mussel Seed with Genetic Profiling

One of the issues facing the mussel aquaculture industry in Nova Scotia is obtaining seed mussels of the correct species. Two mussel species are found in the region, *Mytilus edulis* and *M. trossulus*; the preferred culture species is *M. edulis*. These two species can be difficult to distinguish based on their morphology alone and to complicate the situation further, they are known to form hybrids.

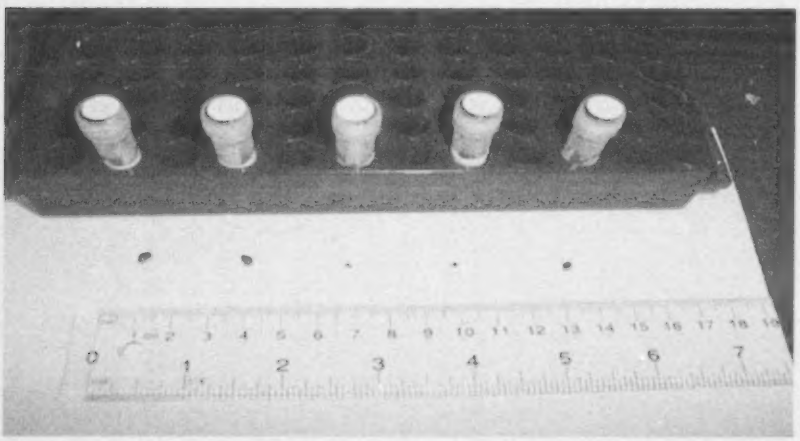
Molecular biology tools, specifically protein (allozymes) and DNA based tests have been developed to distinguish the two species. Technical difficulties have been identified in using these developed assays, therefore in the first phase of this project (April 2005 March 2006) we evaluated the DNA based tests, identified reliable assays and improved these tests so they can be used with more samples for less cost. In the second phase of this project, in collaboration with the Nova Scotia Department of Agriculture and Fisheries, we are using these assays to look at the species composition of seed sized mussels collected around Nova Scotia, in order to identify good regions for seed collection.

Research team : Lorraine Hamilton, Koren Spence, Baudilio Vinuesa, Andrew Bagnall (NSDAF). Submitted by DFO (ACRDP). For information contact Lorraine Hamilton (Email: Hamiltonl@mar.dfo-mpo.gc.ca). Jun. '05 Mar.'08



Mussel species identification gel image results for locus Me15/16.

Below: Species identification using DNA techniques can be done on mussels that are quite small, just a couple of millimeters.



Productivity, thresholds and networking in bivalve aquaculture

Much work has shown that bivalve culture may influence the structure of benthic communities. However, recent work shows that bivalve culture may also increase local secondary productivity, at times to levels greater than that recorded in adjacent "high productivity" environments. How general is this observation? Also, these and other effects are likely a function of the intensity of bivalve farming being done in an area. What density of bivalves can an area hold without modifying benthic communities? What do other researchers think of these ideas and how can research on these subjects be better coordinated? The current project addresses these points.

First, work is being done to test the hypothesis that benthic productivity in mussel culture sites is greater than that in adjacent sandy and eelgrass habitats. Second, we modified organic (mussel faeces) loading rates to develop dose response curves to determine how different stocking densities influence benthic infaunal communities. Third, we held a special session with a keynote speaker on aquaculture environment interactions at the 35th Benthic Ecology Meeting in Quebec City in March 2005. Over 50 people from a dozen countries participated in the session. In addition, future collaborations to further understand the role of aquaculture in the environment are planned.

Research Team: Chris McKindsey, Philippe Archambault, Myriam Callier, Brianna Clyndck. For information contact Chris McKindsey (Email: mckindseyc@dfo-mpo.gc.ca). Submitted by DFO (ACRDP) and RAQ. Nov.'05-Mar.'08.

In search of quality mussel seed in Newfoundland

Increased mussel seed availability has become the number one industry priority for the expansion and continued development of the Newfoundland mussel aquaculture industry. Fisheries and Oceans Canada and the Newfoundland Aquaculture Industry Association in partnership with the Provincial Department of Fisheries and Aquaculture, Memorial University, National Research Council and the Canadian Centre for Fisheries Innovation are working together on a five year project to locate potential sources of mussel seed in Newfoundland. Bays and regions which had not been previously used for this purpose are being examined as possible sites.

Seed collector arrays were designed, constructed and deployed at potential and current aquaculture sites in Newfoundland. Time series studies at two aquaculture sites are ongoing and examine the differences in collection strategies for the two main mussel species of interest (Mytilus edulis and Mytilus trossulus). The study also includes comparing information on how the two different mussel species grow and survive in different bays if they are transported to new sites. Genetic comparisons of the seed from potential sites are also being conducted. Information on the interaction of biological and physical oceanography, particularly current strength and direction, on mussel collection and survival in a cold marine environment is vital to the sustainability and expansion of aquaculture in Atlantic Canada.

Environmental data collection with YSI Sonde profiler deployed by Sean Macneill Badger Bay Mussel Farms and Sharon Kenny DFO.

Research team: Dr. Cynthia McKenzie (DFO), Lynette Carey (NAIA), Cyr Couturier (MUN), Dr. Dave Innes (MUN), Dr. Ray Thompson (MUN), Derek Mouland (NLDFA), Chris Brown (NRC), Marc Kielley (CCFI). Submitted by DFO (ACRDP). For information contact Cynthia McKenzie (Email: mckenziec@dfo-mpo.gc.ca). Jul. '06-Sept. '07

Riverboat flotation for acoustic Doppler profiler collecting current data at mussel aquaculture site with DFO Aquaculture technician Sharon Kenny

Optimizing geoduck out-planting and minimizing environmental impacts

This research examines the possible effects of intertidal and subtidal aquaculture of juvenile geoduck clams (*Panopea abrupta*) and the potential effects of harvesting these clams on the benthic environment. Possible influences being examined include changes in sediment biogeochemistry (i.e. sediment grain size, percent organics, total organic carbon, total nitrogen, sulphide concentration, oxidation reduction potential) and infaunal species diversity. Research is also examining the efficacy of various predator protection technologies. Intertidal research is utilizing PVC tube technology for predator protection and is examining the effects of tube diameter, tube length, and mesh size of screen covering the tubes on clam survival and growth. Subtidal research is examining growth and survival of juvenile clams that are being protected from predators with various biodegradable materials. Another component of the research project is focusing on the development of high-quality broodstock for hatchery production.

Research team: Chris Pearce (DFO), Sean William (DFO)s, Laurie Keddy (DFO), John Blackburn (DFO), Yu Xin An (DFO), Debbie Paltzat DFO), Robert Marshall (DFO). Submitted by DFO (ACRDP).
For information contact Chris Pearce

Stressing out the Pacific oyster

The main goals of this research are to determine the stress response (using multiple stress biomarkers) of Pacific oysters (*Crassostrea gigas*) exposed to high temperature and harmful algae in laboratory conditions, as well as to establish the environmental conditions eliciting a stress response in oysters at a farm site. These are necessary to be able to predict and avoid the occurrence of irreversible stressors, leading to large-scale mortalities of BC cultured shellfish.

The first objective is to test and calibrate, in the laboratory, existing stress indicator techniques [i.e. heat-shock protein (HSP) 70 and neutral red dye retention (NRR)] in Pacific oysters using heat shock treatment as a model stressor. The second objective is to test and compare, in the laboratory, other stress indicators (i.e. metalloproteases and ubiquitin conjugates) for their utility in assessing oyster stress levels. The third objective is to investigate the effect of temperature and harmful algae on stress bio indicators and survivorship of cultured Pacific oysters under laboratory conditions. The fourth objective is to determine, during an entire annual cycle, the in situ levels of these multiple stress biomarkers (HSP 70, NRR, metalloproteases and ubiquitin conjugates) in Pacific oysters at a farm site on the east coast of Vancouver Island, and the environmental conditions at the site. We aim to correlate various environmental conditions with times of high stress in the oysters.

Research team: Chris Pearce (DFO), Maria Maldonado (UBC), David Cassis (UBC), Abayomi Alabi (CSR), Neil Ross (NRC), Nadene Ebell (Odyssey Shellfish), David McCallum (BCSGA). Submitted by DFO (ACRDP). For information contact Chris Pearce, (E-mail: PearceC@pac.dfo-mpo.gc.ca).
Jul. '06-Jul. '08

Mussel aquaculture and ecosystem productivity

Field work to examine the influence of mussel aquaculture on the productivity of benthic communities. Here a small beam trawl is used to capture fish and large invertebrates.

Most work that examines the influence of bivalve culture on the benthic environment to date has focussed on changes in the structure of communities living in the sediments (infaunal communities). Little work has examined the influence of bivalve culture on benthic productivity or on the distribution and productivity of larger organisms, such as crabs and lobster, which may take advantage of an abundance of food and structure provided by bivalve culture. This project examines 1) the influence of mussel culture on infaunal productivity and 2) the distribution and productivity of large organisms. This work is being done on the Magdalen Islands and Prince Edward Island.

Initial analyses show that although infaunal communities differ between aquaculture and non-aquaculture sites, productivity does not. Further, when the productivity of infauna associated with the mussel lines themselves is included in the analyses, "benthic" infaunal productivity is greater in areas with mussel culture than in areas without it. The abundance of large organisms, especially lobster, crabs, starfish, and other predators is much greater within mussel culture sites than in areas without mussel culture. In contrast, the growth rates of these large organisms do not differ between areas within and outside of culture sites.

Research team: Chris McKindsey, Philippe Archambault, Andrea Weise, Paul Robichaud, Lisa Robichaud, Olivier D'Amours, Brianna Clynick, Frédéric Hartog, Chantale Langevin, Catherine Gothout, Guglielmo Tita, Thomas Landry. Financed by AquaNet, ACRDP, DFO, SODIM, RAQ, (mckindseyc@dfo-mpo.gc.ca). Apr.'04-Mar.'07

Juveniles geoduck clams.

Growing Pacific geoduck clams

Research related to geoduck clam (*Panopea abrupta*) aquaculture is being undertaken and touches on several aspects of the culture cycle, ranging from broodstock conditioning to larval rearing, juvenile rearing, and outplanting. Broodstock conditioning experiments will focus on the effect of temperature on gonad development and how this translates into larval success (in terms of growth, survival, and condition). Optimal nursery conditions for post-set clams will be examined by monitoring growth and survivorship under various treatments of temperature, feed type, water exchange rate, stocking density, and substrate type. The potential of a low cost, raft based nursery system for geoduck clam seed will also be examined. This experiment will determine the effect of various gear types, culture depths, and stocking densities on juvenile clam growth and survival. Burrowing behaviour experiments will be conducted to help determine the appropriate season, animal size, and substrate type for outplanting. Through this series of experiments we hope to improve the understanding of the basic biology of these animals as it relates to commercial aquaculture production.

Research team: Chris Pearce (DFO), Robert Marshall (DFO). Submitted by DFO (ACRDP). For information contact Chris Pearce (E-mail: PearceC@pac.dfo-mpo.gc.ca). Apr.'05-Mar.'10

Sources and management of cadmium in Pacific Oysters

Pacific oysters (*Crassostrea gigas*) cultured in British Columbia have occasionally had levels of cadmium (Cd) in their tissues that have been higher than acceptable limits put in place by some international markets. This project's main goals were to: (1) investigate the potential pathways of cadmium accumulation in cultured oysters and (2) identify management tools/practices that may help local shellfish farmers to avoid relatively high cadmium levels in their products. Two sites on Vancouver Island (one on both the east and west coasts of the island) were monitored for one year for cadmium levels in oysters and several environmental parameters (including water temperature, salinity, particulate Cd levels, dissolved Cd levels, and phytoplankton species).

Field results showed that cadmium in oysters followed a seasonal trend, with levels lowest in the spring and summer months. Temperature had the greatest negative effect on cadmium levels in oysters and dissolved cadmium was identified as the primary pathway into the oysters. Phytoplankton were not a vector of cadmium entry into oysters, but rather helped the oysters to depurate the cadmium. Lab depuration experiments were conducted using cadmium-free water and food, but no substantial reduction in cadmium levels was observed after 21 days. Management tools such as monitoring for a certain phytoplankton species or growing oysters at different depths were inconsequential for reducing cadmium concentrations in oysters. The best option for farmers would be to harvest oysters in periods of warmer temperatures, high phytoplankton abundance, and low dissolved cadmium levels.

Research team: Chris Pearce (DFO), Maria Maldonado (UBC), Kristin Ortians (UBC), David Cassis (UBC), Anika Lekhi (UBC), Nadeen Ebell (Odyssey Shellfish), Leah Walberg. Submitted by DFO (ACRDP). For information contact Chris Pearce, (E-mail: PearceC@pac.dfo-mpo.gc.ca) Aug.'04-Jul'05

Cockle broodstock development in British Columbia

Researchers hope to determine the factors that influence cockle broodstock maturation and develop standard operating procedures to ensure consistent production of high quality gametes.

There is significant interest in pursuing commercial aquaculture of the indigenous cockle (*Clinocardium nuttalli*) in British Columbia due to its ability to exist in diverse habitats from sand/gravel to mud and within both the intertidal and shallow subtidal regions. This species is also valued as a traditional food among local First Nations.

A consistent supply of high quality seed is a prerequisite for a successful cockle aquaculture industry and the development of broodstock is fundamental to ensuring the availability of consistent high quality seed. To establish the optimal conditioning methods for broodstock cockles, the effects of biotic/abiotic factors (e.g. temperature, food type, food concentration, etc.) on gonad maturation need to be studied. Before research into commercial cockle production systems can begin, it is necessary to understand the factors influencing broodstock maturation and to develop standard operating procedures to ensure the consistent production of high quality gametes from broodstock.

To this end, our objectives for the project are as follows: (1) To determine the optimal feeding rates and food items for conditioning cockle broodstock; (2) To evaluate the influence of temperature on metabolic rate of adult cockles at temperatures between 5 and 30°C; (3) To establish the Biological Zero Point and the Effective Accumulative Temperatures for gonad maturation; (4) To establish the optimal physical requirements to achieve optimal fertilization rates; and (5) To provide cockle seed to partner companies for research into commercial seeding strategies for maximizing production. Future research proposals are planned to support this work.

Research team: Abayomi Alabi (CSR), Chris Pearce (DFO), Wenshan Liu (CSR). Submitted by DFO (ACRDP). For information contact Abayomi Alabi (E-mail: AlabiA@mala.bc.ca). Nov.'05-Mar.'07

Monitoring invasive species in Nova Scotian waters

Invasive species of tunicates, also known as ascidians or "sea squirts", pose a serious threat to the marine ecosystem. Once established, invasive tunicate populations are expensive and difficult to control, especially in waters with aquaculture and boating operations where attachment structures are present and tunicates may be spread through inadvertent transportation. In the Maritimes, four species of tunicates have caused problems for the shellfish aquaculture industry: *Ciona intestinalis, Botryllus schlosseri and Botrylloides violaceus* (PEI and NS) and *Styela clava* (PEI). A fifth invasive species of concern on the eastern US coast, *Didemnum* sp., has not yet been observed in Atlantic Canada.

An Aquatic Invasive Species (AIS) monitoring project was initiated by DFO in 2006 to determine the distribution of these five species in Nova Scotian waters. Tunicate collectors were placed at public wharves, marinas and aquaculture leases along the coast of Nova Scotia and the Bay of Fundy (New Brunswick). Three targeted monitoring sites were established in areas with tunicate infestations. Public awareness and community participation are promoted by the distribution of brochures and posters and the establishment of an invasive species reporting e-mail and phone line. A better understanding of the distribution and biology of tunicates will facilitate the development of an effective management strategy.

Research team: Bénédikte Vercaemer, Dawn Sephton, Jean-Marc Nicholas, Jennifer Martin, Murielle LeGresley, Andrew Bagnall. Submitted by DFO (ACRDP). For information contact Dawn Sephton (sephtond@mar.dfo-mpo.gc.ca). Apr.'06-Mar.'08

Factors controlling invasion success of tunicates in British Columbia

Currently, there are at least four species of tunicates in British Columbia which are non native and potentially invasive: the solitary tunicate *Styela clava* (club tunicate) and the colonial tunicates *Botrylloides violaceus* (violet tunicate), *Botryllus schlosseri* (golden star tunicate, and *Didemnum* sp. Recent monitoring surveys have detected some of these tunicate species at a variety of shellfish culture leases and marinas around British Columbia. However, it appears that they have not had the same impact on this coast as in Prince Edward Island and Nova Scotia, raising questions about the factors controlling invasion success and establishment.

One area of research aimed at resolving these questions relates to basic tunicate biology and ecology. This project will examine how survivorship, growth, and reproduction of these tunicates are affected by changes in environmental conditions (e.g. temperature, salinity, and desiccation), predation intensity, and physical/chemical treatments (e.g. sodium hypochlorite, acetic acid, freshwater). The results of these experiments should allow us to assess the ability of these tunicates to invade new habitats and the threat that they may pose to other benthic invertebrates within the ecosystem. The research should also enable development of mitigation strategies to prevent further spread of these non indigenous species and undue economic hardship to the shellfish culture industry of British Columbia.

Research team: Chris Pearce (DFO), Thomas Therriault (DFO), Anna Epelbaum (DFO). Submitted by DFO (ACRDP). For information contact Chris Pearce (E-mail: PearceC@pac.dfo-mpo.gc.ca). Aug.'06-Aug.'08

Researchers monitor domoic acid poisoning in Quebec scallops

Domoic acid (DA) is a potent neurotoxin produced by several species of planktonic diatoms belonging to the genus *Pseudo-nitzschia*. Toxic blooms of *Pseudo-nitzschia* can cause shellfish to become poisonous and unfit for human consumption. In scallops, domoic acid is not found in the adductor muscle, but is present in other tissues, thus preventing the harvesting and sale of whole scallops.

For the past several years, two scallop aquaculture sites on Quebec's lower north shore have been afflicted with persistent domoic acid contamination that has prevented harvesting for months at a time. To confirm that blooms of *Pseudo-nitzschia* spp. are responsible for the contamination, a weekly monitoring program has been established in which samples are collected for taxonomic analysis, including imaging by electron microscopy, to identify the presence of *Pseudo-nitzschia* and determine the period of the year in which domoic acid contamination takes place. The ultimate goal is to design a mitigation strategy to minimize the exposure of the scallops to the toxic blooms by temporarily sinking the scallop lines, or moving them to an uncontaminated location.

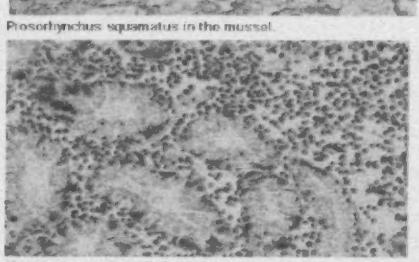
Research Team: Michael Scarratt, Sonia Michaud, Stephen Bates, Yannick Gaudreau, Jean Côté, Isabel Caldéron, Maurice Levasseur. Submitted by DFO (ACRDP). For more information contact Michael Scarratt (email: ScarrattM@dfo-mpo.gc.ca) Apr.'06

Database to compile info on pathogens in Quebec shellfish

The objective of the project is to compile a historical database on the prevalence and intensity of the parasites present in the various shellfish populations at commercial and experimental culture facilities in maritime Quebec. This gives us a temporal and spatial assessment of the distribution of the various pathogens that can have a major impact on economically important shellfish species. With the increase in shellfish culture over the past decade, new pathogens have emerged at culture facilities with the potential to cause significant production losses. The results of the analyses will enable us to monitor changes in the various diseases and to minimize the impact of the proliferation of pathogens through appropriate management methods. In high densities, some otherwise harmless parasites can become very harmful, and intensive culture operations can promote the proliferation of pathogens. For this reason, the project includes a component comparing the parasites present in the mussel populations on both natural and farmed beds.

Research team: Sonia Belvin, Réjean Tremblay, Benoit Thomas, Charley Cyr, Carl R. Uhland For information contact Sonia Belvin (Email: sonia.belvin@partenaires.mapaq.gouv.qc.ca). Submitted by ACRDP and RAQ. Mar.'04-Mar.'07.

Prosorhynchus squamatus in the mussel.



Hemocytic neoplasia in the mussel.

Breeding for MSX resistance/tolerance is seen by the different stakeholders as a long term strategy for recovery of the Bras d'Or oyster in Cape Breton, Nova Scotia.

Developing MSX resistant oyster broodstock in the Bras d'Or Lakes

The American oyster (*Crassostrea virginica*) is an economically, ecologically and culturally important species in Cape Breton, Nova Scotia, but populations have been in decline due to overfishing, degradation of habitats and by the appearance of the MSX parasite (*Haplosporidium nelsoni*) in the Bras d'Or Lakes (Pitupa'q) in 2002. Breeding for disease resistance/tolerance is seen by the different stakeholders (DFO, EFWC, oysters growers, Mi'kmaq elders) as a long term strategy for the recovery of the Bras d'Or oyster. After 3 years of disease challenges in the Bras d'Or Lakes, the timing for the initiation of a selection program is opportune. Oysters that are surviving in the MSX affected areas are exhibiting a level of tolerance and should be considered prime broodstock for initiating a MSX resistance breeding program.

The initiation of a breeding program for MSX resistance in the Bras d'Or Lakes oyster had the following objectives:

- Initiate a rotational breeding plan at the Unama'ki Institute of Natural Resources, Eskasoni, with oysters from specific sites within the Bras d'Or Lakes,
- test the progenies in field sites,
- make recommendations for an expansion/continuation of the breeding program and for future restoration programs.

During the course of the project, it became evident that the surviving oysters collected from MSX infected sites were not in optimal condition. The direct and/or indirect effects of the MSX parasite on gamete production and spawning of the oyster are not clear, but in general, MSX infection impedes on the abilities of an adult oyster to properly reproduce.

Temperature and salinity influence the activity the MSX parasite. Temperatures below 5°C or above 20°C have been reported to control infection. Previous research has also shown that H. nelsoni is inactive or absent at low salinity (10 ppt or lower) and low salinity immersions of oysters have been used as a control measure in Delaware Bay and Chesapeake Bay. A problem with this approach is that oyster gamete production is retarded at salinities below 5 ppt.

The continuation of this project will determine the time-temperature-salinity combinations needed for appropriate gamete production and spawning in MSX infected broodstock at the Unama'ki Institute of Natural Resources, Eskasoni. This is critical to (1) ensure the success on the ongoing breeding program for resistance to MSX initiated in Eskasoni for the Bras d'Or Lakes oysters, and (2) refine timing and zoning of oyster management activities within the Lakes.

Research team: Bénédikte Vercaemer, Barry MacDonald, Koren Spence, Shawn Roach, Mary Stephenson, Charlie Dennis, Shelley Denny, Allison McIsaac, Philip Drinnan, Robert Denny, Shauna Gould, Lewis Clancey. Submitted by DFO (ACRDP). For information contact Bénédikte Vercaemer (VercaemerB@mar.dfo-mpo.gc.ca).
Jun.'06-Dec.'07

DNA-based family identification for Pacific scallops in British Columbia

Selective breeding has only recently been applied to shellfish aquaculture because it is difficult to determine pedigrees when parents produce large quantities of gametes that mix haphazardly in water. Until now, selective breeding has required raising the offspring of each family in separate rearing tanks until they can be individually marked. Aside from the added cost, separate rearing tanks make it impossible to determine how much of the variation in the desirable trait, in this case meat yield, is due to differences in the tanks.

Recent advances in DNA technology make it possible to match parents to offspring, enabling the rearing of multiple families and strains under common or randomly assigned conditions. By rearing strains together, we reduce environmental differences so we can accurately estimate heritability and, thus, potential for selective breeding. In this project, we will develop molecular techniques using microsatellite loci to match parents with offspring and determine whether or not there is a sufficiently broad genetic base in the domesticated strain to support a sophisticated breeding program while minimizing inbreeding depression. We will also undertake preliminary research to locate molecular markers that are associated with higher meat yield in Pacific scallops.

Research team: R. Withler (DFO), and R. St. Clair (Island Scallops). Project Submitted by DFO (ACRDP). For information contact R. Withler (Email: withlerr@pac.dfo-mpo.gc.ca). Sept.'06-May'08

Rapid Response for treatment of the Violet tunicate

The violet tunicate (*Botrylloides violaceus*) and golden star tunicate (*Botryllus schlosseri*), unlike the solitary clubbed tunicate (*Styela clava*), are colonial and thus considered a greater fouling challenge for the mussel industry. They not only reproduce sexually spreading larvae through the water column but also can bud or fragment producing new colonies which will drift and easily spread the tunicates, infesting adjacent and distant leases, depending on environmental conditions and/or anthropogenic effects. Of particular concern is the fact that the violet tunicate can encase and smother the crop. Tunicates are having significant impacts on mussel seed collection, the cost of operating mussel farms and processing the crop.

At the present time, there are no established rapid response measures for these types of infestations, either from a treatment perspective or from a removal (eradication) perspective. The mussel industry, however, is willing to attempt to reduce the impact and spread of tunicate infestation through the removal of a significant amount of the biomass of the violet tunicate by treating all infested mussels leases, including lease gear and mussel crop.

The goal of this project will be to treat all infested leases in Cardigan River in order to reduce the biomass of violet tunicates on mussel socks and culture gear. The main objective of the study will be to assess the effect of this rapid response by evaluating and comparing the recruitment levels in Cardigan Bay utilizing Savage Harbour, as a control bay. A secondary objective will be to monitor the effect of treatment on the infestation levels both on the mussel socks and the bottom under and around the infested leases.

Research team: Neil McNair, Daniel Bourque, Thomas Landry. Submitted by DFO (ACRDP). For information contact Thomas Landry (Email: LandryT@dfo-mpo.gc.ca).
Nov.'05-Sept.'06

Determining the origin of scallop spat used in culture and restocking

The sea scallop (*Placopecten magellanicus*) is a very important species for both fisheries and aquaculture. Bottom seeding in the Magdalen Islands and suspended culture are two approaches adopted by the industry to improve yields. However, both types of operation depend on spat collection in the natural environment, which, in the Magdalen Islands, takes place in a sector different from the one being restocked. The main objective of the project was to determine the origin of the spat by comparing their genetic and metabolic characteristics with those of individuals from different beds.

More than 1,500 adult individuals from 18 beds in the Magdalen Islands, the Gaspé Peninsula, the southern Gulf and the Lower North Shore as well as spat and juveniles from the Fond du Sud Ouest were sampled. The study was not able to identify the origin of the spat because of the absence of genetic or metabolic signatures specific to this site. However, the study did provide basic data on the genetic characteristics of the sea scallop in the Gulf of St. Lawrence that could be used as a reference point during subsequent studies concerning, for example, the effects of environmental variations or aquaculture. There is little genetic differentiation among sea scallops from different regions of the Gulf of St. Lawrence, probably because larval dispersion is significant. The only genetic differences detected are limited to the sites on the Lower North Shore that differ from each other and also from the other sites examined in the study. The genetic differences observed among Lower North Shore sites may be linked to small populations living in relatively closed bays.

Research team: Jean-Marie Sévigny, Réjean Tremblay, Eric Parent, Marc André Roy, Michel Giguère, Georges Cliche. For information contact Jean Marie Sévigny (SevignyJM@dfo-mpo.gc.ca). Submitted by DFO (ACRDP), ISMER and RAQ. Apr.'02-Mar.'06

Genetic tools for selection of crayfish broodstock

Freshwater crayfish culture is carried out primarily in China, the U.S, Europe and Australia, producing a high quality aquaculture product that is in high demand. Fewer than a dozen species are cultured, including the Signal crayfish (*Pacifastacus leniusculus*), that is native to British Columbia. Very little is known of the genetic diversity encompassed in wild or cultured populations of most crayfish species, and little genetic improvement (selective breeding) has been carried out in cultured broodstocks.

Further development of the Signal crayfish as a commercial species requires identification of important components of biodiversity within the species and the subsequent implementation of a broodstock program that will allow continued genetic evaluation and selection for traits such as growth and disease resistance. We will isolate microsatellite loci from Signal crayfish from a genomic library using standard methodologies. We expect to obtain at least eight loci that are polymorphic in *P. leniusculus* and use them to produce multilocus genotypes on individual crayfish collected from several locations in the wild. The loci will also be used to confirm the success of controlled matings (one male with one female) within a hatchery facility.

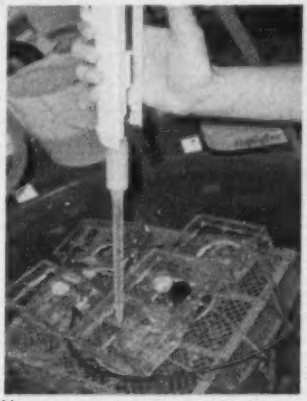
Research team: R. Withler (DFO), and B. Swift (Brunar Consultants Ltd.). Submitted by DFO (ACRDP). For information contact R. Withler (Email: withlerr@pac.dfo-mpo.gc.ca). Sept.'06-Jun.'07

How water temperature effects oyster feeding rates

Domoic acid (DA) is a neurotoxin produced by certain diatom species that are a source of food for filter-feeding mollusks. Although DA does not harm mollusks, it can cause Amnesic Shellfish Poisoning (ASP) in humans. In the spring of 2002, high concentrations of a cold-water diatom, *Pseudo-nitzschia seriata*, resulted in unacceptable levels of DA (greater than 20 µg DA/g) in mussels. This distinctive outbreak occurred in spring instead of Autumn and was detected not only in PEI, but also in NB, Quebec and NS. The unexpected results were the basis for a widespread and lengthy harvest closure directed at most shellfish species, including the American oyster.

The generalized nature of the closure was questioned, given evidence that the uptake and depuration of biotoxins can differ markedly from one shellfish species to another. The objective of this project will test two hypothesis: 1) Cultivated oysters and mussels begin feeding at a similar temperature in the spring; 2) In oysters exposed to low temperatures, feeding rates (as defined by the amount of organic matter absorbed by 1.0 g of tissue over a 24h period) is uncorrelated to animal size. The results may provide a scientific basis for developing the approach for managing shellfish closures by species in Atlantic Canada. This concept aims at optimizing both harvest opportunities and DA monitoring efforts.

Research Team: Fabrice Pernet, Réjean Tremblay, Stephen Bates, Angeline LeBlanc and Thomas Landry. Submitted by DFO (ACRDP). For information contact Luc Comeau (ComeauL@dfo-mpo.gc.ca).



Micro-algae being introduced into bivalve feeding chambers held at 0°C.

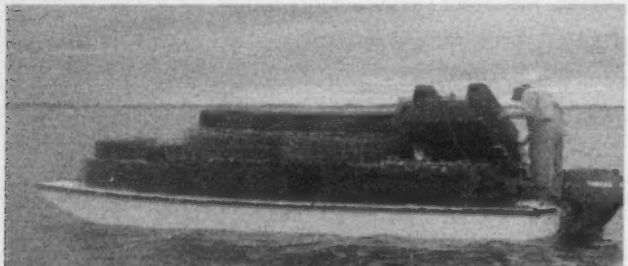
Project to assess localized feed distribution at East Coast oyster farm

Seed is being deployed on shellfish leases with little consideration to localized inequalities in growing conditions. The concentration of food particles may be lower, perhaps frequently, in a given area of a lease compared to other areas. Factors such as currents and water temperature may stress animals to a point of reducing the uptake of available food resources. Shellfish growers could possibly take advantage of localized patterns with the commercial objective of shortening the production cycle. This strategy would be a first step in site management with the objective of optimizing yields. In order to attain that level of production at their site, leaseholders need to assess both the magnitude and persistence of localized features within their leases.

The primary objective of this project is to determine if the current stocking density of cultivated oysters (2,000 oyster bags per hectare) can deplete food resources within the farm at some point during spring, summer and fall.

Research Team: Rémi Sonier, Fabrice Pernet and Thomas Landry. Submitted by DFO (ACRDP). For information contact Luc Comeau (ComeauL@dfo-mpo.gc.ca). Feb.'06-May'08

New Brunswick researchers test oyster gear for bird-deterring effectiveness



Deploying experimental floating oyster gear in eastern New Brunswick.

In New Brunswick, American oyster (*Crassostrea virginica*) aquaculture is mainly carried out using floating Vexar® bags, keeping the filter-feeders in relatively warm and phytoplankton-rich surface waters. However, routine sampling in September 2004, indicated deposition of bird fecal matter on a number of floating bags containing market-size oysters. Some oyster samples exceeded the standard for fecal coliforms, nearly causing total shut down of all oyster production and marketing activities in Eastern New Brunswick, involving some 150 aquaculture sites.

Due to the risk of fecal coliform contamination, suspended culture gear of all types can no longer be used for the mandatory depuration procedure. This lead to a new labour intensive husbandry step, thus the majority of the industry is currently growing oysters using floating gear which must be converted into non-floating gear a few weeks prior to the marketing of oysters.

The industry is considering a low-cost modification which would convert the floating gear into anti-roosting platforms. The industry is proposing two research objectives: (1) evaluate the bird deterring efficiency of four experimental floating gear types, and 2) evaluate whether the birds will use the deterring gear when no other option is made available to them.

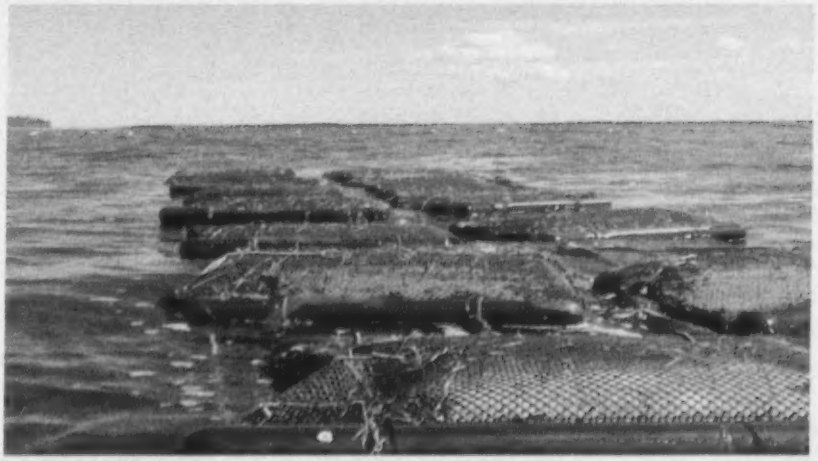
Research team: Fabrice Pernet, Roland Chiasson and Eve-Julie Arsenault. Submitted by DFO (ACRDP). For information contact Luc Comeau (ComeauL@dfo-mpo.gc.ca). Aug.'06-Mar.'08

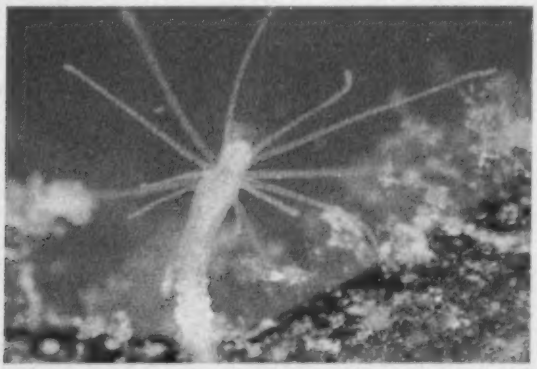
Minimizing fouling and maximizing production in floating bag oyster culture

Aquaculture of the American oyster (*Crassostrea virginica*) in Atlantic Canada has grown significantly in the past decade, largely as a result of the development of suspended bag culture. The recent DFO National Advisory Process on the environmental effects of shellfish aquaculture elucidated many of the important knowledge gaps concerning suspended oysters and their potential effects on the environment. One perceived source of organic matter which may contribute to an environmental impact is the accumulation of fouling organisms on the equipment. If not managed appropriately, this fouling assemblage may contribute substantially to the level of biodeposition, both in terms of faecal matter as well as fall off during maintenance and harvesting.

Typically, shellfish growers develop their husbandry methods on an independent basis through trial and error while endeavoring to optimize the productivity of their leases. The aim of this project is to increase the state of knowledge with regard to the farm management of floating bags in order to improve productivity and minimize environmental impacts. The overall objective is to investigate the relationship between bag turning frequency, fouling levels, organic sedimentation rates and oyster quality.

Research Team: André Mallet, Claire Carver, Simon Courtenay, Matthew Hardy. Submitted by DFO (ACRDP). For information contact Matthew Hardy (Email: HardyMa@dfo-mpo.gc.ca). Jun.'06-Mar.'07





The overall aim of the project is to improve productivity and minimize environmental impacts. Researchers will investigate the relationship between bag turning frequency, fouling levels, organic sedimentation rates and oyster quality.

Introducing oyster larvae into the bouncing bucket

Researchers test bouncing buckets for remote setting of American oyster

The culture of the American oyster (*Crassostrea virginica*) is dependent upon the settlement of wild larvae onto spat collectors and the subsequent transfer of these spats to grow out sites. However, this seeding approach is vulnerable not only to broodstock declines, but also to regulatory transfer restrictions, which can happen unexpectedly due to health issues (e.g. MSX) or the spread of invasive species (e.g. tunicates).

Remote setting of Pacific oysters (*Crassostrea gigas*) on the western coast (Canada and USA) has been researched extensively since the 1970s, and is currently applied at commercial scales. The American oyster, on the other, has received considerably less attention. The natural spatfall at this northernmost range of the American oyster occurs in mid-summer, leaving little time for spat growth prior to the onset of winter. By remotely setting the larvae in early spring, the spat grow-out period can be considerably extended and larger seed oysters can be obtained by the fall of the same year.

We propose to quantify the setting rates of oyster pediveligers in field bouncing buckets. We will compare an innovative remote setting approach (field bouncing bucket) with a more conventional remote setting approach (controlled environment). The goal of the nursery component is to demonstrate that the newly settled spat contained in the experimental bouncing buckets can grow into large seeds by the fall of the same year.

Research team: Rémi Sonier, Fabrice Pernet and Thomas Landry. Submitted by DFO. For information contact Luc Comeau (ComeauL@dfo-mpo.gc.ca). Mar.'06-Mar.'07

Researchers also hope to determine if disease is prevalent in the existing natural population and estimate the potential impact it may have as a component of culture techniques.

Development of Optimal Seeding Techniques for the Culture of Softshell Clam

Various techniques have been developed to enhance wild populations of *Mya arenaria* through cultivation. The impacts of predation, timing of planting of juvenile seed, size of seed, substrate type, density and diseases such as haemic neoplasia, have been found to be significant factors in the survival success of juvenile *M. arenaria*.

The Southwestern New Brunswick Clam Resource Committee (CRC) has acquired a R&D occupational permit in Lepreau Harbour, New Brunswick where a decline in soft shell clam abundance has been observed over the past 15 years. Eastern Charlotte Waterways Inc. (ECW) chairs the CRC and is currently in the second year of establishing techniques for the culture and enhancement of softshell clam.

The objectives of this study are:

- to determine optimal conditions (size, substrate type and manipulation and density) for planting 300,000 hatchery spat currently over-wintering in cages moored at the St. Andrews Biological Station lease site.
- to determine if disease is prevalent in the existing natural population and estimate the potential impact it may have as a critical component of implementation of culture techniques.

Research team: Susan Farquarson (ECW), Nick Vance (ECW), Shawn Robinson (DFO), Mary Stephenson (DFO). Submitted by DFO (ACRDF).
For information contact Shawn Robinson (Email: RobinsonSM@mar.dfo-mpo.gc.ca).

Study to develop and evaluate mussel seed quality standards

The main objective of this study is to develop and assess seed quality criteria based on physiological and pathological health, to assist the mussel industry in reducing the risk of costly high mortalities throughout the growout phase, and more specifically during the pre-sale period that is commonly associated with high environmental (increasing temperatures) and physiological (reproduction) stresses. A secondary objective will be to examine the economical and ecological benefits of new culling techniques to maintain or increase seed quality, in order to optimize the feasibility of mussel seed production and culture in P.E.I. and N.B. while improving the environment interaction of this industry.

In keeping with all of the above information, the overall rational of this project is to develop the tools and scientific capacity needed to optimize and sustain mussel production in P.E.I. and N.B. This project will also provide the basis for a long-term data gathering and analysis system that could be funded by the industry on a national application, similar to other agri-food industry such as the seed classification program of the potato industry. The expertise developed from this project will provide a basis for further research on shellfish farm management.

Research team: Dr. Réjean Tremblay, Nellie Gagné, Dr. Luc Comeau, Dr. Jeffrey Davidson, Mary Stephenson, Thomas Landry. Submitted by DFO (ACRDF). For information contact Thomas Landry (Email: LandryT@dfo-mpo.gc.ca). Jul.'04-Jul.'06

Parasites affecting Atlantic aquaculture development

This project focuses on two parasites affecting shellfish aquaculture in Atlantic Canada; *Prosorhynchus squamatus*, a digenean castrator in blue mussels and Haplosporidium nelsoni, "MSX" in American oysters. The infections pose no human health threat, but have impeded aquaculture development due to concerns about transfers between sites (inter- and intra-provincially) and the potential for spread.

The mussel castrator, *P. squamatus*, is a parasite that can cause castration of the blue mussel (Mytilus edulis), and, in severe infections, weakening and a diminished shelf life. *P. squamatus* was not detected in mussels until 1997, which triggered restrictions on mussel transfers from castrator positive sites. To this end, a total of 5248 mussels (wild and cultivated) from Nova Scotia, New Brunswick, Prince Edward Island and Magdelan Island were analysed. Results suggest that the parasitic mussel castrator is normally a low level and sporadic infection which does not present a significant threat to Atlantic mussel populations. Regular monitoring of mussels for general health status should be sufficient to detect any changes in the low *P. squamatus* infection levels observed in this study.

MSX is a notifiable disease of concern listed by the Office International de Épizooties - OIE based on the devastating effects to oyster stocks this disease has caused along the mid-Atlantic coast of the US. Documenting distribution and monitoring mortalities is essential to ensure the most current information is available to fisheries managers and industry to allow aquaculture activities to continue while protecting uninfected stocks.

Fresh squash of *Prosorhynchus squamatus* released from a blue mussel.

Research team: Mary Stephenson, Anne Ventot, Michelle Maillet, Richard Callant, Neil MacNair, Andrew Bagnall, Abel Noel. Submitted by DFO (ACRDF). For information contact Mary Stephenson (E-mail: StephensonM@dfo-mpo.gc.ca).
Sept.'01-Mar.'06

Rock crabs pictured (man in background) on PEI

Can rock crabs help with mussel culture?

Due to an emerging demand for the rock crab, a directed fishery has evolved over the past twenty years. Concurrently, the mussel aquaculture industry has expanded considerably in many areas overlapping rock crab fishing grounds. One of the important husbandry methods employed by growers to reduce epifauna on mussel socks is to sink their longlines in order to benefit from rock crab predation. This is thought to help the consistency of mussels in a sock as well as to reduce the labour associated in cleaning the mussels destined for the market, but has not been tested scientifically.

Concerns have been raised by mussel growers as to possible impacts of the rock crab fishery within the growing areas. One assumption is that baited rock crab traps may increasingly lure rock crabs away from the aquaculture sites, reducing crab abundance and potentially the longline productivity. By scientifically testing that assumption, the results could improve the management of both industries. Another rock crab abundance risk factor is the presence of the invasive green crab in several areas of PEI, a potential competitor for habitat and food.

The project objectives are:

- to determine whether rock crabs are effectively attracted to mussel socks on a longline;
- to examine whether there is a decline in the abundance of rock crab on and under mussel lines during and following the directed fishery;
- to verify the widespread assertion that rock crabs are beneficial to mussel longline productivity;
- to evaluate the impact of the green crab on mussel line productivity.

Research team: Marc Ouellette, Luc Comeau, Jean-François Maillet and Angeline LeBlanc. Submitted by DFO (ACRDF). For further information please contact Marc Ouellette (OuelletteMC@dfo-mpo.gc.ca).
Nov. 04-Mar. 08

Monitoring the health of soft shell clams and quahaugs in the Bay of Fundy

The shellfish aquaculture industry has grown significantly in recent years, mostly with the culture of the blue mussel and the eastern oyster, and has become an important part of the economy in Atlantic Canada. Research and development for diversification of alternate species such as the soft shell clam (*Mya arenaria*), the quahaug (*Mercenaria mercenaria*) and the bar clam (*Spisula solidissima*) have been particularly targeted because of their high market value. However, culture of these species has not attained a level of sustainability due to issues such as slow growth and erratic mortalities often attributed to limiting environmental factors and experimental husbandry techniques. A profile of diseases that could severely effect the development of the clam culture industry is required.

The goal of this research project will be to evaluate and monitor the health condition of two clam species, the soft shell clam and quahaug, in the Bay of Fundy with the following objectives:

- Update status of endemic diseases such as haemic neoplasia in soft shell clams and QPX in quahogs.
- Screening of non-carrier species for OIE (Organisation International des Epizooties) listed diseases, such as MSX and SSO, found in Atlantic Canada.
- Evaluate the prevalence of shellfish diseases in relation to population dynamics and environmental parameters.

Research team: Marc Ouellette, Mary Stephenson, Angeline LeBlanc, Michelle Maillet and Leah Hamilton (Innovative Fishery Products). Submitted by DFO (ACRDP). For information contact Marc Ouellette (OuelletteMC@dfo-mpo.gc.ca). Jun.'05-Mar.'07

Leah Hamilton of Innovative Fishery Products at St. Mary's Bay, Nova Scotia.

BC researchers monitor benthic impacts of a Pacific oyster farm

This study monitored particulate deposition rates, sediment geochemistry and benthic faunal communities at a deep-water, suspended Pacific oyster farm situated in Village Bay (Quadra Island), British Columbia. Reference stations were positioned at each end of a transect running through the centre of the oyster farm (> 500m from the farm perimeter); additional stations were positioned at 20m and 50m from either side of the farm perimeter; a central station was positioned at the oyster raft located close to the centre of the farm.

Benthic sampling was conducted every 3 months from July 2003 to August 2004. At most sampling dates, the organic carbon deposition rates were significantly higher at the central station (0.4 - 2.5 $gC \cdot m^{-2} \cdot d^{-1}$) than at all other stations (usually <0.5$g \cdot m^{-2} \cdot d^{-1}$). However, the oxidation reduction potential of the sediment below the central station did not differ significantly from that of the two reference stations at any sampling date. Furthermore, sulfide levels at the central station were only significantly higher than the reference stations on one sampling date. These results indicate that the increased organic input from the farm is not leading to consistently reducing sediments or sulfide accumulation in comparison to other locations within Village Bay. These results were consistent with the absence of any notable impoverishment in taxa number or abundance at the central station; these benthic communities were therefore not exhibiting any changes that would be associated with organic enrichment of the sediment.

Research team: Penelope Barnes (CSR). For information contact Penelope Barnes (Email: barnesp@mala.bc.ca). Submitted by BCARDC AQE Fund."

Susceptibility of softshell clams to Haemic Neoplasia

The main objectives of this study were to identify the role of environmental watershed variables on the development of haemic neoplasia (HN) and to determine the potential genetic susceptibility of clams to develop this disease. The validation of a protocol in flow cytometry has allowed increasing diagnostic capacity compared to histology and cytology, the methods traditionally used.

Results indicate that a relatively high prevalence and intensity of HN exists in Prince Edward Island. HN is also detected at low prevalence and intensity in several areas of the Gulf of St. Lawrence. In the literature, occurrence of HN has been correlated with presence of environmental contaminants. After over 50 mm of rainfall in 24 hours, samples (water, sediment and clam soft tissues) were screened for 30 pesticides, including the three compounds most commonly used in agricultural activities. No pesticides were detected by mass spectrograph. Exposure experiments have also been performed to determine whether some fungicides would directly induce HN. After clams had been exposed to fungicides at concentrations ranging from 1 to 100 µg/l for six weeks, results were not conclusive, with no significant induction of the disease being observed in all treatments.

These results suggest that these contaminants may not directly induce development of haemic neoplasia in clams. The results imply a complex interaction along other factors, such as starvation, temperature stress, genetic susceptibility, presence of virus, etc. So far, all tested clam populations show similar susceptibility to develop HN after exposure to positive HN clams.

Results indicate that a relatively high prevalence and intensity of haemic neoplasia (HN) exists among softshell clam populations in Prince Edward Island. HN has also been detected at low intensity in several areas of the Gulf of St. Lawrence. Occurrence of HN has been associated with the presence of environmental contaminants.

Research team: Réjean Tremblay, (UQAR), Jeffrey Davidson UPEI), Thomas Landry (DFO), Emilien Pelletier (UQAR), Franck C.J. Berthe (UPEI), Julie Pariseau (UQAR), Stephanie Lynn Synard (UPEI). For information contact Réjean Tremblay (Email: rejean_tremblay@uqar.qc.ca). Submitted by AquaNet. Jun.'04-Aug.'06.

Study to determine larval abundance and settlement of the blue mussel

For several years, mussel producers in the Gaspé Peninsula have been calling for larval monitoring studies in order to optimize mussel spat collection. However, the relationship between larval abundance, settlement success and success in collecting benthic invertebrate species is a complex issue. In fact, although a number of studies have described a relationship between the abundance of larvae that have reached the pediveliger stage and settlement success, this relationship has not been observed in other studies.

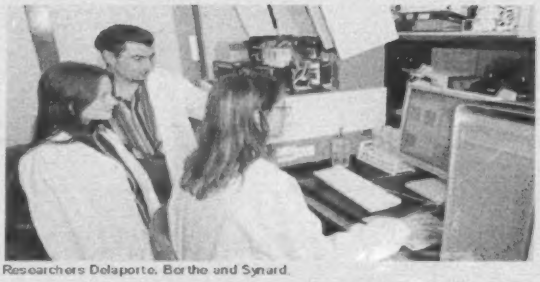
The general objective of this project is to acquire basic knowledge about the mechanisms governing larval distribution in order to determine peak periods of abundance, origin, and diversity of juvenile mussels in the case of two species (*Mytilus edulis* and *M. trossulus*) in the Gaspé Peninsula. Sampling to determine larval abundance and attachment success was carried out at the two production sites from June to October 2006. Characterization of the environmental factors required for modelling hydrodynamic conditions was also carried out during the summer of 2006, along with the histological analyses of wild and farmed adult mussels required for the description of the reproductive cycle. The other laboratory analyses will be conducted during the next two years.

Research team: Nathalie Rayssac, Réjean Tremblay, Jean-Marie Sévigny, Benoit Thomas and Vladimir Koutitonsky. For information contact Réjean Tremblay (rejean_tremblay@uqar.qc.ca). Submitted by DFO (ACRDP), MAPAQ, SODIM and ISMER. Apr.'06-Mar.'09.

Advancing mollusc diseases diagnosis in Canada

Infectious diseases are one of the major causes of economic loss in mollusc aquaculture and fisheries. Reliable and sensitive methods for detection of pathogens are essential to prevent their introduction or enable their management. Traditionally, diagnosis has been mostly based on histology. It is generally recognised that histology requires a high level of training and expertise. For this to be useful, we propose networking solutions for histology.

Real time histology sessions are established between distant laboratories by use of VNC technology associated to internet based phone solution. The project commonly uses real VNC and Skype. Training sessions have successfully been tested. It is expected that to become an increasingly used resource by surveillance networks, early warning and emergency response plans, as well as service, teaching and training facilities will be necessary. However, histology still holds limitations and there is a call for more rapid and sensitive methods.



Researchers Delaporte, Berthe and Synard.

The second aspect of our project was to develop flow cytometry procedures using specific antibodies to rapidly detect infectious disease along with the physiological status of the animals. In a first step we have developed a protocol for double labelling of neoplastic haemocytes based on propidium iodide stain and 1E10 as a way to assess the disease status of soft shell clam *Mya arenaria* with regards to haemic neoplasia. The validation of the procedure is still in progress; our next step is to develop similar procedures for infectious disease such as bonamiosis (*Bonamia ostreae*) of the European flat oyster, *Ostrea edulis*.

Research team: Frank Berthe (UPEI), Dave Groman (AVC), and Maryse Delaporte (UPEI). For information contact Frank Berthe (Email: fberthe@upei.ca). Submitted by AquaNet.
Jan.'05-Apr.'07.

Physiological and genetic bases of growth in the soft-shell clam

Knowledge of the physiological and genetic characteristics governing the growth of individuals is essential to the development of farm management methods that will eliminate individuals with poor growth potential. This goal can be achieved by applying selective methods or developing hatchery strains. However, it is important to preserve the resistance of the populations to environmental stresses and disease. The acquisition of sufficient genetic and physiological knowledge can significantly reduce this risk.

The main objective of this project is to determine the physiological and genetic characteristics that differentiate soft-shell clams, Mya arenaria, on the basis of their growth, in order to evaluate the possibility of developing a farm management method that maintains high growth rates without weakening the farmed stocks. To date, more than 300 individuals from different size classes have been sampled and transferred to the Pointe-aux Pères station (ISMER) for a period of acclimatization to laboratory conditions. The experiments will be conducted during the winter of 2007.

Research team: Bruno Myrand, Réjean Tremblay, Jean-Marie Sévigny and Lise Chevarie. For information contact Réjean Tremblay (rejean_tremblay@uqar.qc.ca). Submitted by SODIM, ISMER and ACRDP DFO.
Apr.'06-Mar.'07

Management of aquaculture site selection via regional Habitat Classification

Advances in survey instruments and Geographical Information Systems (GIS) can help improve the efficiency and scope of information available and provide a more eco-system view of environmental assessments, which can streamline the site assessment process for both regulators and farmers. This project evaluates using these innovative instruments for site assessments compared to traditional approaches.

In the spring of 2005, three coastal bays in Guysborough County, NS (Country Harbour, Marie-Joseph Harbour, and Tor Bay) were selected for study and plans were initiated for a comprehensive field sampling program. A GIS database was constructed from various sources, identifying sampling locations, as well as hypothetical farms for intensive surveys by remote sensing. A website for the project was also created to update partners on the progress of the project; refer to http://myweb.dal.ca/jgrant/Guysborough.html for more information and images of the summer field program.

Field sampling was initiated in 2005 and all three bays were surveyed intensively with the remote sensing instruments (echosounder, Acrobat), and benthic-pelagic sampling (sediment grabs, water sampling, underwater video) was carried out. All data have since been added to the GIS database. The dataset will be further analysed using GIS and statistical methods. Analyses and reporting of the results will be completed by December 2006.

Research team: Jon Grant (Dalhousie U.), Peter Cranford (DFO), Rosalina Carreau (UVic). For information contact Jon Grant (Email: jon.grant@dal.ca). Submitted by AquaNet Website: http://myweb.dal.ca/jgrant/Guysborough.html
Jan.'05-Dec.'06.

Bacterial breakdown of marine shellfish toxins

Paralytic shellfish poisons, or PSP's are produced by marine dinoflagellates and can accumulate in the flesh of cultured bivalves such as clams, mussels and scallops. As their name indicates, PSP's are toxic to humans and can cause death in those who consume contaminated shellfish. Some marine bacteria have been observed to grow on and decompose certain PSP toxins in vitro.

A strategy was developed in which toxin-degrading bacteria were fed to toxic shellfish in order to accelerate the speed of detoxification. Specific objectives were to screen toxic bivalves for bacteria that could degrade Paralytic shellfish poisoning (PSP) and/or domoic acid (also called Amnesic Shellfish Poisoning) in situ, isolate the enzyme(s) that degraded these toxins, and use a probiotic approach in depuration ponds by encapsulating the active bacteria and feed these to the toxic shellfish.

Toxic bivalves were successfully screened for bacteria that could degrade Paralytic Shellfish Poisoning (PSP) and/or domoic acid in situ. The ability to introduce the bacteria in large enough numbers and their effectiveness in completely breaking down toxins resulting in innocuous end products still needs to be determined. The outcomes of this project could result in significant benefits to the shellfish aquaculture industry if the appropriate toxin-degrading bacterial culture could be introduced into shellfish during commercial depuration procedures.

Research team: Tom Gill (Dalhousie University), Rafael Garduno (Dalhousie University), Michael Quilliam (Dalhousie University), Monica Bricelj (NRC-IMB). For information contact Tom Gill (Email: tom.gill@dal.ca).

Selective breeding for the bamfield Huu-Ay-Aht abalone

The challenge with designing a breeding program for highly fecund broadcast spawner like the pinto abalone is to avoid inbreeding. Most hatcheries do group spawning where 3 or 4 females are spawned with 3 or 4 males. However, our pedigree analysis with five microsatellite markers showed that in some spawning groups nearly all the larvae have been produced by only one female and one male. By using tentacle clips to monitor the relatedness of the broodstock we can maximize the number of parents that contribute to each generation, and increase the rate at which we can develop a new fast growing aquaculture strain of abalone.

To establish the breeding program we are doing a genetic evaluation, assessing the genetic merit, and predicting the response to the genetic selection program. The economically important traits include survival rates, age at harvest, and meat quality. We compared the economic values of these traits after genetic improvement to their base values, and determined which traits have positive effects on the profitability of abalone aquaculture operation. Our breeding program will be applicable to any aquaculture species that has a high fecundity and prolonged larval stage that are reared in hatcheries without the facilities to rear each full-sibling family separately.

Research Team: Elizabeth Boulding, Yajie Liu, Matt Lemay, Ian Mcmillan, Rashid Sumaila and Jane Tosh in collaboration with Bamfield Huu-Ay-Aht Community Abalone Project and Ruth E. Withler (DFO). For further information contact: Elizabeth Boulding: (Email: bouldinge@uoguelph.) Submitted by AquaNet
Jan.'05-Apr.'07

West Coast abalone researchers are undertaking a genetic evaluation of the species, assessing the genetic merit, and predicting the response to a genetic selection program. The economically important traits include survival rates, age at harvest and meat quality. They compared the economic values of these traits after genetic improvement to their base values and determined which traits have positive effects on the profitability of abalone culture operations.

Collecting soft-shell clam spat in Quebec

Juvenile soft-shell clams (*Mya arenaria*) can be supplied from three different sources: the harvesting of juveniles on natural beds, hatchery production and collection in the natural environment. The transfer of juveniles, although promising, was temporarily halted after several unsuccessful attempts. Efforts to produce spat in a hatchery were carried out in the last few years at the Centre aquicole marin de Grande-Rivière, but with mixed success. However, recent work carried out in the Magdalen Islands shows that it is possible to achieve good collection success by using various pelagic and benthic collectors. This type of test was reproduced with some success with benthic collectors (nets) in 2005 on a mud flat (Cran à Cagnon) on the Upper North Shore. However, the results achieved with other types of collectors as well as at other sites with a sandy substrate were mixed. In light of these results, the industry proposed repeating the tests at Cran à Cagnon in order to validate the observations made in 2005.

Experimental plots with nets for clam spat collection.

Gonadosomatic development was monitored from April to September in the Forestville sector in order to pinpoint clam spawning time. In the weeks following spawning, nets measuring 2.4 m x 7.6 m (mesh size of 6 mm x 8 mm) were positioned at the lower limit of the intertidal zone. The nets were placed directly on the flat (the ends buried in a 30 cm deep trench) in order to promote the recruitment of the new cohort of clams. The experimental design included four experimental plots with nets and four control plots (without nets), all installed in June 2006. Three other types of pelagic collectors were tested at the same time in the infralittoral zone. An initial series of samples was collected prior to installation of the nets in June 2006; a second series of samples will be collected in the fall of 2006 and a final series in the spring of 2007.

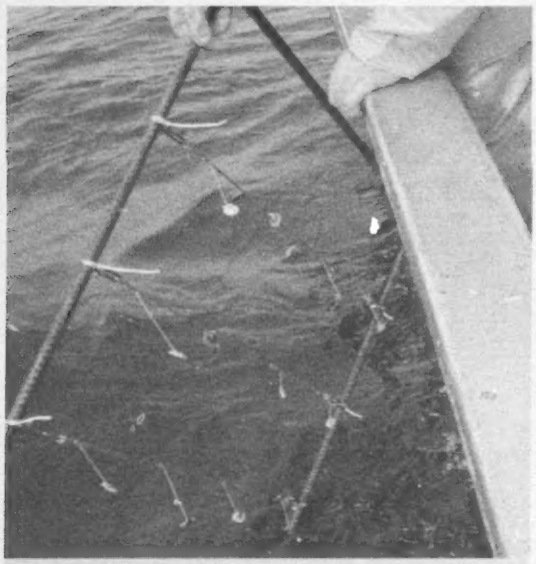
Research team: M. Giguère, S. Brulotte, J.-M. Bélisle, Claudia Boisvert and Bernard Tremblay. For information contact Michel Giguère (Email: GiguereM@dfo-mpo.gc.ca). Submitted by SODIM and DFO
Apr.'06-Mar.'08

Controlling the clubbed tunicate in PEI

The clubbed tunicate (*Styela clava*), is a recent invader to Prince Edward Island (PEI) waters, and has had a particularly negative impact on mussel culture in the Murray River region. They attach in high densities to mussel socks and equipment, compete for food resources, foul equipment and could have a devastating effect on the PEI mussel industry. This research project focuses on determining the cause of death in tunicates to assist in identifying specific, environmentally acceptable chemical or biological solutions to target tunicates. The project also examines the effect of tunicate treatment on the physiological fitness of mussels and the ecology of the mussel sock.

Initial findings indicate that exposure to 5% acetic acid for two minutes results in mortality of the clubbed tunicate regardless whether the siphons are submerged or not. While the acetic acid has limited effect on some species in the aquatic environment, such as the lunar dove shell, it causes short and long term negative effects on the population dynamics of others, such as caprellid shrimp. The acid treatment causes mussel seed mortality, but does not affect mussel growth or genetic characteristics. The research will provide valuable information to formulating policies and standard operating procedures for treating tunicates with acetic acid.

Research team: Jeff Davidson (UPEI), Gerald Johnson (AVC); Thomas Landry (UNB). For information contact Jeff Davidson (Email: davidson@upei.ca) Submitted by AquaNet Jul.'03-Jul.'06.



Optimizing scallop collection in the Magdalen Islands

Research carried out in the Magdalen Islands over the last three years has established that weekly collection monitoring is a reliable tool for tracking changes over time in the attachment of scallops and undesirable species. This tool, which requires little expertise, is relatively easy for the industry to use. The results to date indicate that, with this tool, scallop growers can avoid the periods of peak mussel and hiatella attachment that occur before the beginning of scallop attachment by delaying the immersion of their collectors. The tool could also enable producers to decide to immerse collectors later in the season since weekly collection monitoring makes it possible to characterize changes in scallop attachment over time with some degree of reliability.

In the fall of 2003, the results of collector analysis during weekly monitoring revealed that very few hiatella, smomia and scallops had attached to the collectors. The same work in 2004, with recovery of a portion of the collectors by divers, revealed that very few organisms had detached during the process of raising the collectors into the boat, while the post-larvae (0.3 to 0.4 mm in size) could have passed through the mesh of the bags (2 mm). Another possible explanation of the low collection success for certain species could be linked to the effectiveness of the collector. In fact, a collector in which the collection substrate is not optimally conditioned (covered by a biofilm) would appear to be less effective for certain species.

In 2005, a study to verify this issue was conducted by the technical team from the Centre maricole des Îles-de-la-Madeleine in collaboration with the Pétoncles 2000 company. The goal was to evaluate whether it was possible to optimize collection on collectors conditioned in tanks before immersion in the sea. The results showed that a collector conditioned for two weeks in filtered seawater before being immersed in the sea provided a better collection substrate for scallops and, occasionally, for hiatella. However, despite these results and the few organisms that attached to the unconditioned collectors, weekly collection monitoring remains a reliable and accessible tool.

Research team: Carole Cyr, Georges Clicha, Jacques Richard, Jean-Guy Turbide, Claude Poirier, Michèle Langford, Francine Aucoin. Submitted by DIT MAPAQ. For information contact Centre maricole des Îles-de-la-Madeleine (Email: stmim@mapaq.gouv.qc.ca).

The project investigates various approaches to planning and management of coastal areas, and addresses the potentially conflicting interests of marine conservation, coastal tourism, First Nations and the needs of local communities.

Combining shellfish aquaculture and marine protected areas

This project explores approaches to planning and management of coastal areas that will address the potentially conflicting interests of marine conservation, coastal tourism, First Nations interests, and the needs of local communities. It includes examining perceptions of residents in the Gulf Islands, marine scientists and environmental groups regarding aquaculture in a nearby marine protected area (MPA). A second component assesses the role of stakeholder involvement in protected area decision making and compares these with other jurisdictions. The third component focuses on First Nations aspects regarding shellfish aquaculture and MPAs, taking into consideration the tensions between existing treaty processes, municipal regulations and constitutional litigation. This project will provide a comparison with experiences of indigenous groups in New Zealand.

The research to date has resulted in a comprehensive literature review of a collection of marine health indicators (biological, social, managerial), a web-based survey with marine scientists regarding the various indicators of marine health in a marine protected area, a focus group study with shellfish growers and a survey of residents of the Gulf Islands, BC, to measure their respective perceptions of the compatibility of shellfish aquaculture and MPAs; a study of legal implications of First Nations' involvement in shellfish aquaculture; and a comparison of New Zealand and British Columbia. Key policy and governance issues for planning and managing MPA were identified as well as a lack of knowledge about shellfish aquaculture among many stakeholder groups, resulting in a negative bias against shellfish aquaculture.

The research in New Zealand included several public lectures including at the National Institute for Water and Atmospheric Research (NIWA) and the New Zealand Institute for Economic Research. NIWA's Maori Research Unit has expressed interest in working with the Canadian researchers on a project that would partner a First Nation community on the west coast with a Maori community where NIWA has secured three-year funding to run a small-scale, shellfish aquaculture training project.

Research team: Rick Rollins (MUC), Jeremy Rayner (MUC); Chris Tollefson (UVic). For information contact Rick Rollins (Email: rollinr@mala.bc.ca). Submitted by AquaNet. Apr.'03-Mar.'06

Dynamic of haemic neoplasia in soft-shell clams

Some of the molecular mechanisms of haemic neoplasia (HN) in the soft-shell clam, *Mya arenaria*, have been identified. Several studies have demonstrated the role of proteins belonging to the p53 family in the process of this disease. This makes haemic neoplasia and *Mya arenaria* an interesting model in comparative oncology. While p53 is expressed in both normal and leukaemic cells, previous studies have shown specific expression of a p73 in leukaemic cells. Mutation of the gene coding for p53 has also been suggested in the process of the disease. More recently, a mortalin-based sequestration of p53 in the cytoplasm of leukaemic cells is proposed as an essential mechanism of neoplasia. However, there is still little information on the dynamic of this family in the course of the disease.

Our study focuses, in a first attempt, on expression of p53 and p73 genes in leukaemic clams. An HN positive clam population is monitored by western blots and quantitative RT PCR. Detection of mutation is based on SSCP and western blot using monoclonal antibody Pab240. With time, our main objective is to identify the molecular actors involved in the development of leukaemia.

Research team: Réjean Tremblay (UQAR), Jean-Marie Sévigny (UQAR), Franck C.J. Berthe (UPEI), Ahmed Siah (UPEI), Julie Pariseau. For information contact Réjean Tremblay (Email: rejean_tremblay@uqar.qc.ca). Submitted by AquaNet. Jun.'06-Jul.'07

Studying Shellfish Disease at the Pacific Biological Station

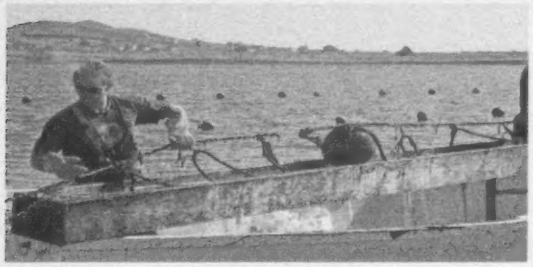
Since the late 1980s, the Shellfish Disease Research Unit at the Pacific Biological Station in Nanaimo has been investigating infectious diseases of shellfish that occur on the Pacific coast of Canada. Discoveries include the identification and description of several new disease agents and parasites including the following Protista: *Labyrinthuloides haliotidis* a thraustochytrid lethal to newly settled abalone; *Perkinsus qugwadi* that seriously curtailed the development of scallop culture in B.C.; an unnamed pathogen of spot prawns (SPP); *Margolisiella kabatai* and *Pseudoklossia semliana*, in the kidney of native littleneck clams and mussels, respectively; a ciliate *Stegotricha entertikos* that utilizes the digestive tract epithelial cells of oysters; and a rickettsia-like eukaryote in spot prawns that affects market acceptability.

Current research includes identifying the biology of *Mikrocytos mackini* which is of international significance to the production of oysters in cool habitats and determining the distribution and identity of a coccidia that infects the kidney of abalone. Recently, the Unit has taken on the challenge of supporting the new National Aquatic Animal Health Program to provide laboratory diagnostic support to the Canadian Food Inspection Agency in establishing shellfish products from B.C. as free of OIE (World Organisation for Animal Health) listed diseases.

Research team: Susan Bower and Gary Meyer. Submitted by DFO (ACRDP). For information contact Susan Bower (Email: Bowers@dfo-mpo.gc.ca).

Methods used to experimentally expose molluscs to pathogens (from top left): inoculation, slurry of infective stages mixed with algal feed, and cohabitation with cultured stocks in lantern nets on long lines and in vexar pouches on the beach.

Brine treatments used to improve mussel collection in Quebec



A team from the Centre maricole des Îles-de-la-Madeleine (CeMIM) has been working for several years to characterize the process of attachment used by mussels and other organisms at the region's main collection site.

The effectiveness of brining as an agent for controlling starfish, the main predator of mussel spat, was demonstrated several years ago. The experiment revealed that the ideal duration of treatment is around 30 seconds, and that the optimal treatment period can extend over several weeks. However, mechanization of operations make it necessary for the benefits of such an operation to be validated on a commercial scale.

In the summer of 2005, the Société de développement de l'industrie maricole du Québec (SODIM) therefore joined forces with the CeMIM team in order to verify the cost-effectiveness of the operation of brining collectors infested with starfish. By simply comparing sections of collector lines brined in August and unbrined sections on the same lines, it was estimated that each of the two mussel growers in the region could have harvested several million additional young mussels in the fall by brining their collectors.

While it would have cost each mussel grower in the Magdalen Islands approximately $4,000 to brine all their lines, the operation would have enabled them to harvest an additional 12 to 16 tonnes of spat. It is reasonable to assume that the additional spat production obtained by brining could generate net revenues of several thousand dollars. The project resulted in a series of recommendations which were distributed to all mussel growers in Quebec to encourage them to adopt the practice.

Research team: François Bourque, Bruno Myrand, Jules Arseneau, Francine Aucoin, Yvon Chevarie, Michelle Langford, François Gallien, Jacques Richard, Annie Renaud. Submitted by DFT MAPAQ. For information contact Centre maricole des Îles-de-la-Madeleine (Email: stmim@mapaq.gouv.qc.ca).

Investigating the effect of skeleton shrimp on mussel spat recruitment

In 2003, mussel growers in the Carleton region reported unprecedented populations of skeleton shrimp on spat collectors and holding lines. This phenomenon appeared to be accompanied by relatively low spat collection rates.

The purpose of this project is to determine whether skeleton shrimp are harmful to mussel culture. To achieve this goal, the project will comprise the following components: 1) study of mussel spat set density and skeleton shrimp biomass as a function of depth; 2) study of the diet of skeleton shrimp; because the stomach contents of skeleton shrimp are frequently too degraded to permit direct identification, we must use an immunological approach. This method is based on detection of the presence of mussel tissue by examining the agglutination response of an appropriate antibody when placed in the presence of material from the digestive tract of skeleton shrimp; 3) study of the biomass and size/age structure of existing skeleton shrimp populations as a function of depth and period in the season; 4) study of the effect of various line weight line maintenance protocols on skeleton shrimp populations.

The few preliminary results currently available indicate that skeleton shrimp populations on spat collectors decreased in 2006; it also appears that during the 2004-2005 period, skeleton shrimp did not adversely affect mussel spat collection, unlike other epibionts. Using new weight lines reduces the number of skeleton shrimp and hydrozoans, while manual cleaning of the weight lines has no effect. Mussel spat collection tends to be higher on the control weight lines. The results of immunochemical tests indicate that skeleton shrimp do not feed on mussel larvae or spat.

Research team: Marcel Fréchette, Bernard Sainte-Marie, Christian Tuwotte, Linda Girard, Marie-Claude Marquis (MLI, DFO); Réjean Allard. For information contact Marcel Fréchette (Email: FrechetteM@dfo-mpo.gc.ca). Submitted by SODIM Jul.'04 Mar.'07

Researchers test new intermediate culture techniques for scallops in the Mingan Islands

The scallop farming strategy generally relies on spat collection, subsequent transfer of the spat to pearl nets, followed by bottom seeding or transfer to lantern nets. Each of these steps is very labour intensive. One way of minimizing the effort invested in these operations is to bypass one or more of the steps in the production chain described above. An approach being considered in this project is to allow the spat in the collection bags enough time to reach a sufficient size so that the pearl net step can be skipped. One condition required for this scenario to work is the number of spat attached to the bags must be high enough for the operations to be worthwhile, yet low enough to prevent overcrowding in the collection bags. The biomass-density relationship can be used to study this aspect.

To study this relationship, we collected spat at two sites in the Mingan Islands and at different heights from the bottom, which normally yields a gradient in the initial numbers. As the project continues, spat are then recovered after one year and two years in the collection bags. The following variables are studied: the size of the scallop and other shellfish specimens, the numbers of the various species and the height of the bags from the bottom. We will also conduct sampling of the fluorescence and the temperature of the water column. The initial results indicate that growth varies with height from the bottom, which is a classic response. These results also indicate the existence of interspecific competition among scallops (*Chlamys islandica*) and other shellfish (*Hiatella arctica* for example).

Research team: Marcel Fréchette, Linda Girard (MLI, DFO); Martin Guay (Centre aquacole de la Côte-Nord). For information contact Marcel Fréchette (Email: FrechetteM@dfo-mpo.gc.ca). Submitted by SODIM. Aug.'04 Mar.'09.

Shellfish Longlines

In previous work, Institute for Ocean Technology (IOT) researcher Dr. Wayne Raman-Nair, in collaboration with Mr. Pierre Bergeron and Marc Gagnon of BIOREX Inc. of Quebec, has developed numerical models of submerged shellfish longlines. These models have been developed into a software product that allows shellfish growers to estimate loads induced by environmental and routine servicing actions. The current work is continuing to develop the models and software to provide more accurate predictions.

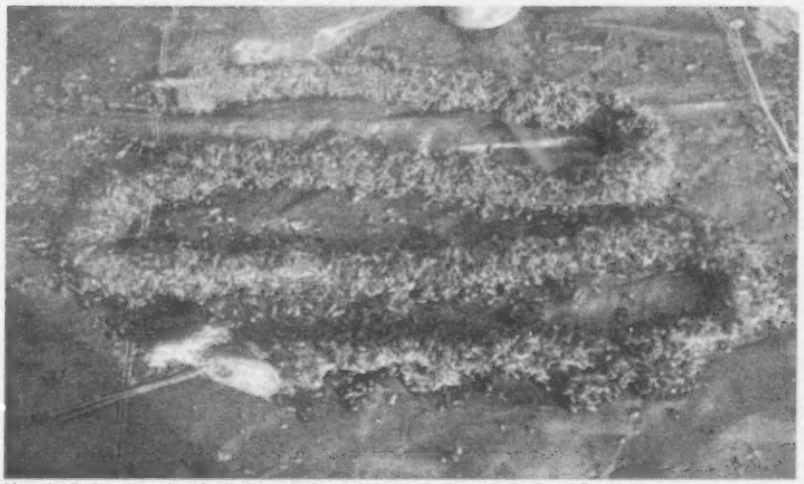
In 2005, IOT and Biorex conducted in situ drag trials on various components of a typical shellfish farm including spat collectors, various buoys with and without fouling and the shellfish socks themselves. The data from these experiments was used to provide more accurate drag coefficients for the simulation software and to quantify the effects of marine fouling in increasing the drag. Following this a second generation simulation package was developed that allows the motions and orientations of the shellfish socks themselves to be more accurately determined. This software is currently undergoing testing and evaluation at Biorex.

Research team: Wayne Raman-Nair, Pierre Bergeron and Marc Gagnon (Biorex Inc.). Submitted by NRC. For information contact Bruce Colbourne (Email: D.Colbourne@nrc-cnrc.gc.ca).

Monitoring mussel larvae and spat in the Gaspé Peninsula

For a second year, the peak presence of mussel larvae about to undergo metamorphosis and the peak level of mussel spat attachment were identified in the two mussel culture sectors of the Gaspé Peninsula: Tracadigache Bay and Gaspé Bay. Every week from mid May to mid-October, at each of three selected sites, mussel growers collected samples by pumping for 10 minutes between 1 and 8 m from the surface; the samples were then filtered using three screens (780, 390 and 80 µm).

Results obtained in the Cascapedia Bay sector included the appearance of small larvae (new cohort) beginning in mid June. In the Gaspé sector, three cohorts of small veliger larvae were observed, as in 2004, including a very large peak around mid-July. Until late June, the average size of the larvae in Cascapedia did not exceed 200 µm and although larger sizes were found in Gaspé slightly earlier, their density remained very low. As in 2004, the density of the spat collected on the lines in Gaspé was higher, but the average spat size was nearly half that observed in Cascapedia.

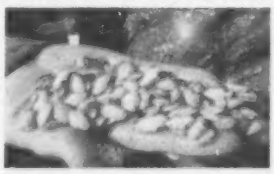


Mussel collector retrieved to identify the optimal period of spat attachment in the Gaspé Peninsula.

Research team: B. Thomas, N. Rayssac, R. Tremblay and J.-M. Sévigny, R. Allard and staff, N. Bouchard, J. Bourgoing, J. Cauvier, J.-C. Cloutier, D. Fortin, R. Juneau, S. Morissette and staff, and M. P. Turcotte. Submitted by MAPAQ, SODIM, ISMER and DFO. For information contact Benoit Thomas (Email: benoit.thomas@mapaq.gouv.qc.ca).

Development of soft-shell clam culture in Quebec

Clam culture is generating interest in Quebec, particularly in the Magdalen Islands. "Myiculture aux Îles-de-la-Madeleine" (MIM), a five year research and development program, was carried out between 2000 and 2005. A new five-year program, MIM-II, began in 2006. Several activities of the first and of the new program were conducted in parallel.



At the present time, work is focused on ensuring a supply of spat, specifically with benthic mats (Astroturf). Suspension collectors are also being tested. In the fall, the young clams from the collectors measured 8 mm on average. Overwintered in suspended structures under the ice cover, they are still too small to be seeded the following summer. A pre-growout phase must therefore be added to obtain 15 to 20 mm clams for seeding operations. It has been discovered that this size minimizes losses by predation, dispersion and natural mortality. Various nursery approaches are being compared (FLUPSY, floating bags and even buckets filled with sand) to determine the most efficient and most cost-effective method. Several experimental seedings are carried out each year. The experimental plots are covered with a net (4 mm mesh size) during the entire first summer season. Growth and recovery of the seeded clams are then monitoring by regular sampling. Economic scenarios are developed with the data obtained and regularly updated.

Research team: Lise Chevarie, Bruno Myrand, Réjean Tremblay. Submitted by DIT MAPAQ. For information contact Bruno Myrand (Email: bruno.myrand@mapaq.gouv.qc.ca).

Why and how mussel attachment strength varies

During the summer period, fall-offs of mussels from suspended socks can be significant. Reducing these losses would increase the profitability of mussel culture operations. These fall-offs are most likely related to the strength of the attachment of the mussels to each other as well as to the culture substrate. Better knowledge of changes in attachment strength over time and of the factors that influence it would make it easier to devise solutions.

Researchers seek a better knowledge of changes in mussel attachment strength over time and the factors that influence it.

Research into this problem was carried out in 2004 (late June to mid-October). The weakest attachment strengths were observed from mid-July to mid August. Attachment strength then regularly increased during the fall, to levels as much as 2.3 times higher than in mid-July. The work was repeated in 2005, beginning in late May. The main findings were: (1) the significant decline in attachment strength in summer appears to be associated with spawning, (2) the increase in the fall appears to be associated with increased water turbulence, (3) the difference was approximately 1.9 X between extreme values, and (4) the mussels were more strongly attached in 2005 than in 2004. A number of other biological and environmental parameters are currently being analyzed in order to more clearly identify the factors involved in the variability of attachment strength on socks.

Research team: Andrée-Anne Lachance, Bruno Myrand, Réjean Tremblay, Jean-Marie Sévigny, Vladimir Koutitonsky, Emily Carrington. For information contact Bruno Myrand (Email: bruno.myrand@mapaq.gouv.qc.ca). Submitted by MAPAQ, ISMER and ACRDP DFO. Apr.'05 Mar.'06

The project aims to monitor scallop spat losses and determine the best time for large scale retrieval of the collectors.

Researchers evaluate scallop spat losses in Gaspe Bay

Monitoring sea scallop collectors in the Gaspé Peninsula and the Magdalen Islands revealed that 70% to 90% of spat were lost before the collectors were raised at the end of the summer. Adoption, by the project proponent operating in Gaspé Bay, of an intermediate culture strategy to optimize collection therefore requires that the condition of the collectors first be determined and that changes over time in terms of scallop size and losses be monitored.

The number and size of scallops on the collectors will be estimated by sampling, to be carried out every two weeks by divers who will retrieve five collectors per line on each of three lines. Between late May and early November, up to 14 sampling periods could occur. The 15 collectors will be cleaned and sorted in the laboratory in the days following their retrieval in order to determine the progression of losses and growth of the scallop spat and the amount of fouling, thus helping to identify the best time for large-scale retrieval of the collectors by the proponent. Based on the results of the first season of the project, a progressive loss of spat was in fact seen from the start of sampling in mid June until late July. From that point on, the average quantity of sea scallop spat per bag remained stable until the end of collection in early November.

Research team: B. Thomas, M. Giguère, J. Richard. Submitted by MAPAQ. For information contact Benoit Thomas (Email: benoit.thomas@mapaq.gouv.qc.ca).

Growth of sea scallop spat studied in Gaspe Peninsula

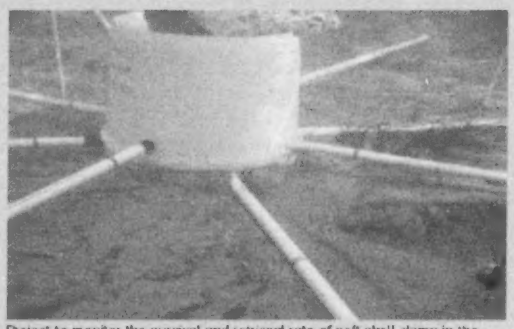
Monitoring of the growth of sea scallop spat recovered from the collectors of a project proponent in the fall of 2000 and from collectors during the 2003 collection optimization project was continued in lots maintained in Cascapedia and Gaspé bays. The various lots from the 1999 collectors, collected, sorted and transferred to nets in 2000, reached an average size of nearly 100 mm by the fall of 2005. The spat from the 2003 collectors reached a size of nearly 60 mm in the same period. In the various cases, few differences were observed in growth between the lots maintained in Gaspé and in Cascapedia. Manipulations at low salinities during spring monitoring in Gaspé is probably responsible for the high mortalities observed between the spring of 2005 and the next monitoring phase conducted in the summer. Despite these incidents, the monitoring demonstrated that the production cycle, although not optimized, could extend over more than five years, including collection.

Research team: B. Thomas. For information contact Benoit Thomas. Submitted by MAPAQ, SODIM, and DFO. For information contact Benoit Thomas (Email: benoit.thomas@mapaq.gouv.qc.ca).

Recent measurements of the dispersion of soft-shell clams seeded in the Malbaie barachois

Between 2003 and 2005, research was carried out on soft-shell clams (*Mya arenaria*) in the Malbaie barachois in order to measure their displacement distance, determine the direction of these movements and estimate their survival as well as the return rate following seeding.

A total of 480 clam specimens, 35-40 mm in size, were measured, mm bored and tagged with a small metal pin. The clams were spread over 10 plots. On each plot, 48 clams were placed in groups of six, at 20 cm intervals, on each of the eight axes of a grid oriented according to the cardinal points. During subsequent monitoring, the clams were located using a metal detector along the axes of the grid, relative to their initial position. In October 2003 and July 2004, all the clams on a certain axis were retrieved and five new plots containing 240 clams from a second size class (25-30 mm) were added and monitored until the fall of 2005. Despite annual fluctuations, commercially seeded clams are expected to have very limited movements. The majority of the clams did not move. Where movements were calculated, they may have been influenced by other environmental conditions and the direction of the currents at the time of seeding.



Project to monitor the survival and retrieval rate of soft shell clams in the Malbaie barachois in the Gaspé Peninsula.

Metal detector used to locate tagged clams in the Malbaie barachois in the Gaspé Peninsula.

Research team: B. Thomas, M. Giguère and S. Brulotte. Submitted by MAPAQ, SODIM, and DFO. For information contact Benoit Thomas (Email: benoit.thomas@mapaq.gouv.qc.ca).

The Sustainable Shellfish Aquaculture Initiative at Simon Fraser University

In February 2002, Simon Fraser University was awarded a 5 year National Science and Engineering Research Strategic Grant entitled "Towards a sustainable shellfish industry". The overall long term objective of the strategic grant was to provide to the shellfish industry required information for sustainable farming of the foreshore without harm to the environment. The specific objectives of the research project were to determine how shellfish farming practices influenced:

(1) the geochemical cycles of carbon, phosphorous, and nitrogen within the intertidal region
(2) species diversity, abundance, and distribution within the intertidal
(3) migratory birds (shorebirds and sea ducks), which rely on the intertidal for at least some part of their life history.

These objectives were conducted in three geographically distinct areas on the coast of British Columbia, including Baynes Sound, Malaspina Complex and Desolation Sound and Barkley Sound.

Research outcomes are now being written and submitted to peer review journals for publication.

Research team: Leah Bendell Young, Sean Boyd, Rob Butler, Dan Esler, Patricia Gallaugher, Ron Ydenberg. For information contact Leah Bendell-Young (Email: bendell@sfu.ca).
Website: http://www.sfu.ca/coastalstudies/ssai

Investigating the Effects of Clam Nets

Predator nets used for culturing Manila clams in British Columbia are laid on intertidal sediments and thereby could possibly interrupt tidal flows and influence larval settlement and sediment properties. The influence of intertidal clam netting on the distribution of settling pediveliger larvae was investigated by examining early recruitment patterns of Manila clam larvae (*Venerupis philippinarum*) in relation to predator netting. Recently settled clams (<600 µm shell length) were sampled from netted and non netted sites in Baynes Sound, on the eastern side of Vancouver Island, British Columbia. Plots with netting and high density of adult clams experienced lower levels of settlement. Settlement was variable annually with 2003 experiencing an order of magnitude less recruitment than 2004.

Sediment properties (sediment grain size, organic carbon and inorganic carbon) were also compared between netted and non netted plots. No difference was seen in the sediment properties measured except for slightly higher levels of organic carbon beneath nets; this was likely due to the higher number of adult clams beneath the nets. Overall, no measurable increase in sedimentation beneath netting was noted; however, decreased settlement beneath netting was observed in the year when overall settlement was high.

In addition, laboratory tests were run using flumes to examine the retention of competent clam larvae within flumes with netting on the bottom. No difference in the retention of clam larvae was observed due to netting or sediment treatments.

Research team: Daphne Munroe, R. Scott McKinley, William Fennell, Neil Bourne and Doug Bright. For information contact Daphne Munroe (Email: dsmunroe@interchange.ubc.ca) Submitted by NSERC. Jan.'02-Aug.'06

Student volunteers Kent Williamson and Edith Billington take shellfish samples on a night tide.

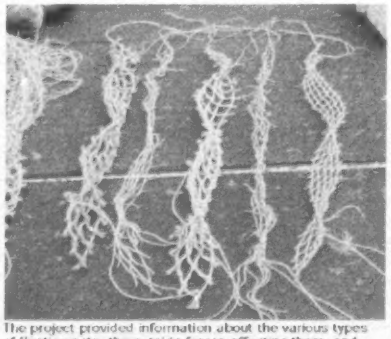
Daphne Munroe taking a settlement sample.

Researchers seek to optimize floating nets for shellfish rearing

In Quebec, submerged floating nets have been used for commercial mollusc farming since the mid 1980s. At first, these rearing structures were designed on the basis of techniques developed elsewhere, especially Prince Edward Island, and numerous changes were made over the years to adjust them to the severe conditions that prevail on Quebec coasts. Despite this, Quebec sea farmers are still having a number of technical problems, especially when rearing sites are relatively unprotected from waves, winds and ice. The high risk of floating net loss and damage represents a major limiting factor for new firms and industry growth.

Despite all the experience accumulated by producers and the ingenious solutions they have found to enhance farm yields there remains poor understanding of how the nets and their anchorages behave when swept by currents, winds and swells. So it is not surprising to find that we have few specific criteria for shaping nets and choosing anchorages to reflect the physical features of rearing sites. These criteria are desirable, however, to further stabilize floating nets deployed at sea and cut the costs of manufacturing, installing and maintaining these structures. This is why the Regroupement des mariculteurs du Québec (RMQ) and SODIM have mandated the Biorex firm to help Quebec sea farmers learn more about rearing structures.

This initial mandate produced certain basic rules to govern the design of floating nets and make them more stable at sea. The research also provided information about the various types of floating nets, the outside forces affecting them and how differently shaped floating nets behave, and should make for better long-term buoyancy management. As well, this study included the development of simulation software to help sea farmers configure their submerged nets to reflect the features of their rearing sites. This software accommodates various net configurations (changing, for example, buoy sizes and numbers, rope length and elasticity or bearing line height above the bottom) and enables us to calculate the nets' position and inclination above the bottom, tension in lines and the pull of anchorages in different current and swell conditions.



The project provided information about the various types of floating nets, the outside forces affecting them, and how differently shaped floating nets behave in different conditions.

However, the main factor limiting the use of this software is the shortage or absence of data for a number of parameters in the model. The simulation results could be made more accurate by adding data on the environmental characteristics of rearing sites (including the speed of currents), the mass of rearing media in the water and the mechanical properties of the components (the drag coefficient when dirt is present, resistance to the pull of anchorages and the elasticity of ropes).

Therefore, the BIOREX firm was handed a second mandate to conduct new digital simulations with more accurate data for the modelling parameters. This new study, which began in fall 2005 to continue over two years, will increase the accuracy of the parameters used to model the submerged floating nets and conduct simulations that will optimize the design of these nets by incorporating data on resistance to the pull of anchorages and abrasion of mooring lines.

Despite the range of phenomena that can arise from year to year, optimizing the use of floating nets by computer modelling of rearing parameters will certainly give sea farmers an added tool to further improve their rearing practices.

Research team: Robert Vaillancourt. Submitted by SODIM. For information contact Robert Vaillancourt (Email: Robert.vaillancourt@sodim.org).

New seeding strategies developed for the sea scallop

Seeding of juvenile sea scallops has been carried out annually in the Magdalen Islands for more than a decade in order to compensate for the drastic drop in wild stocks that occurred in the late 1970s. The commercial strategy chosen involved annual seeding of scallops 20-40 mm in size following intermediate culture in a lagoon for approximately nine months.

The first objective of the project will be to assess the information available concerning optimal scallop size at seeding. The second objective will be to conduct a field study in order to assess the survival of scallops seeded directly from collectors without sorting (5-20 mm) as compared with the survival rate of scallops seeded directly from collectors after sorting (5-20 mm), scallops that go through an intermediate culture phase in a lagoon for approximately nine months according to the conventional method (20-40 mm), and scallops that have a grow-out period of approximately one year and nine months (40 mm and over).

Each strategy will be evaluated for scallop survival rate and these data will be compared with the associated costs to determine the most cost-effective method.

Research team: Hugo Bourdages, Madeleine Nadeau, Sylvain Vigneau, Robert Vaillancourt, Michel Giguère, Mélanie Bourgeois and Patrice Goudreau. For information contact Hugo Bourdages (Email: BourdagesH@dfo-mpo.gc.ca). Submitted by MAPAQ, SODIM, ACRDP DFO. Oct.'06-Mar.'10

Producing blue mussels on "self-operating collectors"

In eastern Canada, mussels are reared in socks suspended from fixed lines. The lines are maintained at a constant depth and require regular maintenance inspections and significant efforts for spat collection and socking. In addition, suspension culture involves periods of intense activity that leave very little time for other tasks. The purpose of this project is to complete the development of a mussel culture strategy that would allow fishers to engage in suspension culture while avoiding conflicts with the fishing season, which would offer a possibility for diversification of the fishers' traditional activities.

One possible way to achieve this objective is to culture mussels on "self-operating collectors", which would require very little line maintenance and would make it possible to avoid socking. One possible drawback is that because the seed would not be graded to size, product quality would be more variable. The project includes comparing the commercial production of the "self operating collectors" and of traditional socks, monitoring the depth of the "self operating collectors", conducting a bioeconomic analysis and establishing the biomass-density relationship for the mussel populations of the "self operating collectors" in Cascapedia Bay.

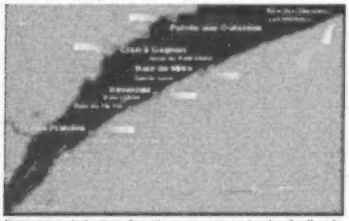
Research team: Marcel Fréchette, Myriam Lacharce-Bernard, Linda Girard, (MLI, DFO); James Wilson, Francis Bilodeau (UQAR); John Himmelman (Laval University); Éric Bujold. For information contact Marcel Fréchette (Email: FrechetteM@dfo-mpo.gc.ca). Submitted by SODIM. Apr.'03-Mar.'07

Growth of clams in the St. Lawrence Estuary

A number of studies have shown that temperature, food quality and availability, immersion time, salinity, dissolved oxygen, density of individuals, substrate, current, exposure to waves, pH and quantity of suspended matter can affect the growth of the soft-shell clam (*Mya arenaria*). In addition to these factors, the effect of biological factors on growth, such as sexual maturity, must also be considered. Research carried out in Quebec in the last few years has indicated that the site, where a number of the above-mentioned variables are factors, had a predominant effect on clam growth. In the St. Lawrence Estuary, the variables affecting clam growth are poorly documented at present. Of the above-mentioned variables, sexual maturity, immersion time and food supply were identified as priorities for in-depth evaluation during this project.

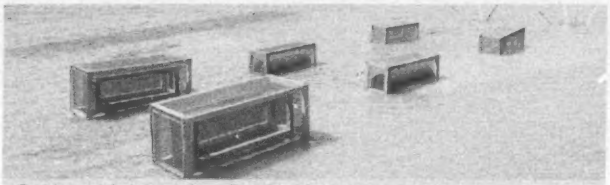
Installation of an experimental plot for in vivo growth of the clam.

In 2005, clam size at sexual maturity was studied for seven beds in the St. Lawrence Estuary and the Gulf of St. Lawrence. The preliminary results of this research indicate that size at maturity is similar in the case of clams from the Estuary and Gulf of St. Lawrence, but smaller in that of clams from the Magdalen Islands. Research aimed at measuring the effects of immersion time and food supply was initiated in tanks at the Maurice Lamontagne Institute, and in the field on five beds in the St. Lawrence estuary. The variability, both intra-bed and inter-bed, of growth, survival and dispersion rates was studied. The knowledge gained through this project will contribute to our understanding of the biology of the soft-shell clam and help in the selection of seeding sites suitable for clam culture in the Estuary and Gulf of St. Lawrence.



Experimental sites for clam growth in tanks (yellow) and in the field (grey).

Research Team: M. Giguère, S. Brulotte, J.-M. Bélisle, Marie-France Dréan, Annabelle Bourget, Bernard Tremblay, Claudia Boisvert and Madeleine Beaudoin. For information contact Michel Giguère, (Email: GiguereM@dfo-mpo.gc.ca). Submitted by SODIM and DFO (ACDRP).
Apr.'05-Mar'07



Experimental designs used to collect clam spat.

Researchers test spat collection methods for the soft-shell clam

The objectives of this project were to evaluate four spat collection techniques for soft-shell clam (*Mya arenaria*) in an open environment on the north shore of the estuary and Gulf of St. Lawrence in order to estimate their respective collection success and identify the advantages and disadvantages of each of the techniques used. Field work was carried out in 2005 on the Cran à Gagnon and Pointe-aux-Outardes flats on the Upper North Shore. Collection trials were conducted on these two beds using nets placed directly on the substrate. Collection trials using three different types of cages as well as Astroturf mats were also conducted near the nets at the Cran à Gagnon site. Random sampling of the sediments was carried out in June and October 2005 on all the experimental plots and the control plots. The cages and mats were sampled in October 2005 only.

The results obtained at Cran à Gagnon indicated that the collection rate was 10 times higher under the nets than in the control sites without nets. The results obtained with the other types of collectors placed at Cran à Gagnon were mixed. The results achieved at Pointe-aux-Outardes with nets were negligible. Three months after deposition of larvae, the average size of the clams collected was less than 3 mm. Of the various collection techniques used, the net appears to be the most promising.

Research team: M. Giguère, S. Brulotte, J.-M. Bélisle, Marie-France Dréan, Marie-Karine Maltais, Claudia Boisvert and Bernard Tremblay. For information contact Michel Giguère (Email: GiguereM@dfo-mpo.gc.ca) Submitted by SODIM and DFO
Apr.'05-Mar'06

Shetland Island mussel spat collectors tested in Quebec

The mussel collectors and rearing media used in Quebec generally consist of a rounded section of rope. The mussels settle there, but with time and growth their density becomes very high for the available surface. This situation is thought to cause the release of some of the mussels, generally at harvest time.

A 2005 trade mission of Quebec mussel farming industry representatives introduced them to the collection and rearing systems used by mussel farmers in Scotland and the Shetland Islands. Some of them practise the SMART system with wide-mesh, heavy gauge netting as the collection and rearing medium. One of the major Shetland Islands producers uses this principle for spat collection and rearing on collectors, cutting handling and thus labour requirements. These collectors consist of the edges of fishing nets dropped from a head line. This is felt to give the spat a bigger surface to settle and grow on. The success of the harvest would thus be improved.

Discussions on returning from the mission came up with the hypothesis that this approach to collecting and rearing on collectors would be of interest for Quebec and a project was developed. The main objective being to test the efficiency of mussel spat collectors made of net mesh edges. The secondary objective is a preliminary assessment of the advantages and drawbacks of this kind of collector for rearing purposes.

The project is ongoing in Cascapédia Bay with input from a mussel farmer. The spat was collected in early July 2006, and these structures will be monitored until the summer of 2008. Five types of media are being tested, all made of nets originally intended for trawling. Each collector is deployed vertically with the top attached to the net's head line at a depth of 1 m. A weight is attached to the collector's lower part to keep it in a vertical position: collector depth thus varies from 1 to 2.60 m.

At the time of deployment, the netting is rolled up and lashed with biodegradable wire, making a cylinder 1.60 m long. After the collection period, the wire is destroyed and the medium resumes its form as an edge, increasing the attachment surface and reducing mussel density by unit of length on the medium, though without cutting the number at the foot.

Regular 1.60 m collectors have also been deployed as controls beside these experimental collectors. Twelve experimental collectors of each type (thus 60 in all) and 12 regular collectors were deployed in July on the collection site of the farmer working with the project. Three of the 12 collectors of each type of medium will be brought up for monitoring purposes at four periods, September 2006 (after collection), November 2006 (before wintering), June-July 2007 (after one year of growth) and June-July 2008 (after two years of growth).

As well, information on ease and time of manufacture and use will be noted throughout the project so the advantages and drawbacks of these collectors can be weighed in both economic and biological terms. Recommendations for the industry will be developed with the final report.

Research team: Robert Vaillancourt. Submitted by SODIM. For information contact Robert Vaillancourt (Email: Robert.vaillancourt@sodim.org).

Byssus production in the blue mussel: effect of environmental agents

Mussels attach themselves to the culture substrate by their byssal threads. The ability to produce byssus is therefore a necessary condition for the success of a mussel growing operation, both at the time of socking and later during the production cycle. The factors that influence the byssus production rate include temperature, salinity, cutting of the byssus, agitation of the water, tidal system, reproductive cycle and the presence of predators, to name but a few. However, laboratory research findings suggest that the metabolic cost of byssus production is high. Food availability can therefore be expected to also play a role in the ability to produce byssus.

In order to establish quantitative relationships between environmental factors and byssus production, we placed mussels of different sizes in individual transparent enclosures, which made it possible to count the individual byssal threads. The enclosures were placed in chambers installed in series, through which natural sea water flowed, but were arranged in such a way that the food supply became less concentrated downstream because of feeding by the mussels upstream. In addition to establishing this food gradient, we studied the effect of temperature, water flow in the chambers and number of mussels. For all these conditions, the byssal threads were either cut completely or left intact. The byssal threads were counted three times a week in order to study the possibility that body growth and byssus production compete for available energy. By measuring the feeding rate immediately following byssus cutting, we can detect the presence of experimental stress brought about by the cutting.

A preliminary analysis of the results indicates that byssus production increases with temperature, but only with a low water flow rate, that it is very sensitive to the amount of food available, that water flow does not have a direct effect, and that cutting the byssus causes a clear reduction in body growth rate.

Research team: Marcel Fréchette, Sophie Brillon, Linda Girard (MLI, DFO); Cédric Bacher (IFREMER). For information, contact Marcel Fréchette (Email: FrechetteM@dfo-mpo.gc.ca).

Experimental sites : LARSA laboratory – Ferme piscicole des Bobines – Pisciculture Mainard.

Interprovincial Partnership to foster sustainable freshwater aquaculture

The Interprovincial Partnership for Sustainable Freshwater Aquaculture Development, formerly known as the Interprovincial Initiative for Sustainable Freshwater Aquaculture Development, has the mission to promote the sustainable development of freshwater aquaculture in Canada. It proposed an innovative approach by establishing R&D partnerships with Canadian experts in order carry out specific projects related to the issues voiced by the industry stakeholders. The objectives of this organisation are then to:

- Create a concerted consensus on industry priorities
- Identify projects with R&D or pre-commercial development potential and gathering research and/or technology transfer expertise required to accomplish these projects
- Promote the creation of synergies between all groups involved, and thus, avoid duplicating R&D efforts and encouraging an optimal utilisation of the resources.
- Search and channel research funding towards projects that originate directly from priorities established by the industry

The Partnership is mainly composed of a representative from each provincial or regional freshwater aquaculture association.

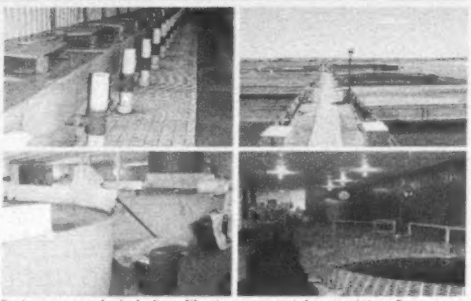
Feed Trials in Canada

In 2004-2005, the first of a series of projects under the name "Feed Trials in Canada" was carried out to compare the performance of salmonids fed with Danish feed against the performance of salmonids fed with commercial feed available in Canada.

The Danish trout feed industry has been regulated as to the composition of the grower feeds that are allowed to be used by the farmers. Their feed composition regulations relate to the maximum amount of phosphorus and nitrogen and ash, minimal level of energy and digestibility, and maximum feed conversion ratios permitted.

The Canadian study allowed researchers to test the practice of using "high energy" feed on a small scale under a laboratory-controlled environment (brook trout of 60-200 g and rainbow trout of 400-1000 g) and on a large scale under normal commercial conditions (rainbow trout 200-500 g, brook trout and arctic charr of 60-200 g). The studies showed that the use of high performance feed, Danish feed or similar, complying with strict environmental regulations helped improving the growth performances (FCR, SGR) as well as environmental performances (reduction of phosphorus discharge in effluent). A greater accessibility to high performing feed will allow Canadian growers to achieve their environmental targets while keeping production costs competitive.

Research team: Grant Vandenberg, Éric Boucher, Richard Moccia, with the collaboration of Pierre Dubé, Robert Vaillancourt, Sylvain Larreau, and Karen Tracy. Additional Research team: Guy Ouellet, Normand Roy, Yves Boulanger, François Roberge, Francis Dupuis and Jean Maheu. Submitted by DFO (ACRDP). For information contact: Charley Cyr email: CyrCh@dfo-mpo.gc.ca or Doug Geilling email: geilingd@dfo-mpo.gc.ca



Tests were conducted at an Alberta commercial recirculating farm, a Saskatchewan commercial cage system, and the Alma Aquaculture Research Station.

Subsequent Trials

In 2006, a second series of feed trials followed the first one. This time, the study was extended to include different systems and larger size fish and was carried out exclusively on rainbow trout. The performance of the Danish feed was assessed and compared to the performance of the currently used feeds in two Alberta commercial recirculating farms (trout of 60-200 g), on a Saskatchewan commercial cage system (trout of 650-1000 g) and in a lab-scaled controlled environment at the Alma Aquaculture Research Station (trout of 750-1500 g). The results of this study are showing similar trends to those in the previously carried out feed trials where Danish feed helped improve the growth performances (FCR, SGR) as well as environmental performances (reduction of phosphorus discharge in effluent). On the other hand, the development of new formulations from Canadian feed manufacturers tends to reduce the gap between the performances of Danish feed and the performances of the traditional Canadian feed.

Research team: Grant Vandenberg, Éric Boucher and Richard Moccia with the collaboration of Lorne Louden. Additional Research team: Dean Foss, Lorne Louden and Max Ménard. Submitted by DFO (ACRDP). For information contact: Doug Geilling email: geilingd@dfo-mpo.gc.ca

Experimental work was done at Pisciculture Mont-Tremblant, Laboratoire LARSA, and Pisciculture des Allehanys.

Another project (2006) to study the commercial, environmental and physiological performances of Brook trout fed with low phosphorus/high energy, newly formulated Canadian feed permitted researchers to investigate the effect of fishmeal replacement and fat content in commercial feed on brook trout performance. The lab study at LARSA was carried out to examine the effects of the experimental feed on growth performances, on the liver functions (cellular and physiological levels), on the body composition and on phosphorus waste. Subsequently, field trials were to be conducted on commercial farms to validate the differences in performance, body composition and phosphorus output. The results that will emerge from this study will allow a better understanding of the relationship between brook trout performance and fat content in feed. This may lead to development of new feeds which could be very important in the Quebec context taking into account the importance of the species and the environmental regulations associated with nutrient releases in receiving waters.

Research team: Grant Vandenberg, Éric Boucher, Keith Were, with the collaboration of Pierre Dubé. Additional Research team: Yves Boulanger and François Roberge. Submitted by DFO (ACRDP). For information contact: Charley Cyr email: CyrCh@dfo-mpo.gc.ca

Testing aquaponics in Alberta

Aquaponics facilities contain plant and fish components together in one re circulation system. Water leaving the fish tanks, rich in nutrients, is used for plant growth, while the plants are used as biofilters to reduce the build-up of nitrogenous and mineral wastes in water returned to the fish tanks. An extensive study during first year of operation demonstrated the technical feasibility of aquaponics technology under Alberta growing conditions.

The project focused on high value crops for economic analysis of aquaponics operations in Canada. The data on yields of both fish and greenhouse crop components has been collected during 2005/06. A hatchery has been added to the facility in Brooks to optimize aquaponics operation.

Economic analysis has been conducted by theEconomics and Competitiveness Sector of AAFRD. The analysis showed that as much as 70% of gross revenue may come from the greenhouse portion in aquaponics operations. The aquaponics minisystems have been built for the project and has been in operation for one year confirming that the same principles can be applied in a much smaller scale. These trials produced the highest crop yields reported in the literature for soilless culture without use of mineral fertilizers.

Research team: Nick Savidov, Ph.D., Eric Hutchings, Nabi Chaudhary. Submitted by Alberta Agriculture Food and Rural Development and ACRDP DFO. For information contact Nick Savidov (nick.savidov@gov.ab.ca). Apr.'06-Mar.'08

Aquaponics operation in Brooks, Alberta Agriculture, Production Greenhouse. The facility was build in 2002 using model of University of Virgin Islands developed by Dr. James Rakocy.

Aquaponics mini-systems constructed to increase the experimental aquaponics capacity in Alberta. The mini-systems were used in studies to develop control strategies to maintain high crop yields without introducing contaminants into the fish produced. The project was also funded by University and Alberta and NSERC Canada.

Quebec forms aquaculture strategic knowledge node

The Réseau Aquaculture Québec (RAQ) is a network of researchers (academic, provincial and federal government researchers, CEGEP professors) involved in aquaculture research in Québec. RAQ researchers are involved in the three research activity areas targeted by AquaNet, i.e., enabling communities, healthy ecosystems, and creative product. While our principal strength is at the ecosystem level, we have also integrated humanities and social sciences into our research program from the beginning of our activities and are now working to develop some expertise in marine biotechnology.

RAQ's general goal is to work on the development of an economically and environmentally sustainable aquaculture sector in Québec. Specific objectives with respect to an AquaNet geographic knowledge node are: 1) to promote networking of Québec researchers and industry with Canadian industry and AquaNet researchers from other geographic sectors; 2) to promote AquaNet activities towards our local partners; 3) to participate in building international partnerships (e.g., Marine Genomics, France–Canada network on larval production); 4) to participate and promote training of HQP; 5) to promote sharing of technical and human resources; 6) to help our researchers to be successful in getting aquaculture research funds at the provincial and federal levels; and 7) to work on information dissemination to the industry, government, and the public.

Submitted by AquaNet. For more information Contact Céline Audet (Email:Celine_Audet@uqar.qc.ca)

Mobilizing Aquaculture Knowledge: AquaPort.ca as Semantic Web

As a new Canadian industry, aquaculture has a high knowledge demand as it strives to become more competitive and sustainable. Embracing industry, academia, government and communities, the aquaculture sector in Canada will increasingly depend upon knowledge exchange that is mediated by the web. Without such a vehicle, opportunities for innovation and research will be lost and the ability to engage society in learning about aquaculture will be limited.

Aquaport.ca, the web portal for Canadian aquaculture, will effectively bridge the gaps by delivering "just in time" knowledge resources. It will adapt content to users' needs and ensure its "findability." It will provide a one-stop gateway to an array of knowledge resources such as scientific, industry and government publications, workshop and conference proceedings, research-in-progress information, fact sheets, online seminars and forums, directories of expertise and services, and news feeds. It will be built upon a robust database anchoring a dynamic web-based user interface. Designed to be open and publicly accessible, it will be based on the "build once – deploy for many uses" principle, and be scalable to grow with the Canadian aquaculture community.

At least 10 students from across the country will be involved to help build the content and solve knowledge transfer problems. AquaPort.ca is a collaborative effort between the Research team and the Canadian aquaculture community, embracing industry, government and academic partners and supporters. Among the collaborators so far are the British Columbia Aquaculture Research & Development Committee, the Canadian Aquaculture Industry Alliance, the Aquaculture Association of Canada, le Société de développement de l'industrie maricole, le Réseau Aquaculture Québec and the DFO Aquaculture Collaborative Research and Development Program. The Institute for Coastal Research at Malaspina is the project's institutional lead.

Research team: Bill Pennell, Tim DeJager, Céline Audet, Duane Barker, Thierry Chopin, Cyr Couturier, Rich Muccio, Jeremy Rayner, Rick Rollins, Barbara Thomas, Joy Wade, Carmen Léger. Submitted by AquaNet. For more information contact Tim DeJager (dejagert@mala.bc.ca).
Website: www.aquaport.ca

Jul. 06 - Jun.07

The new state-of-the-art Charlottetown Aquatic Animal Pathogen and Biocontainment Laboratory will enable research into virtually any aquatic animal-disease or pathogen.

New DFO lab to enhance disease investigation

The Charlottetown Aquatic Animal Pathogen and Biocontainment Laboratory (CAAPBL) is an important constituent of the DFO Aquatic Animal Health Reference laboratory network. CAAPBL is located within a Canadian Food Inspection Agency (CFIA) laboratory and administrative facility in Charlottetown, PEI. Live aquatic animal holding capacity has been retro-fitted within former large animal Containment Level 3 areas. Thus, CAAPBL provides a state of the art biocontainment facility that enables DFO to support virtually any aquatic animal-disease/pathogen investigation.

It is the only facility in North America that has the structural components CAAPBL provides or the stringency of waste treatment in support of aquatic animal biocontainment. CAAPBL activity will focus on research in support of the National Aquatic Animal Health Program, i.e., research on aquatic animal-disease interactions (health/disease/pathogen-specific), diagnostic tools development and emergent disease and epizootic investigations. Besides live animal holding capacity there is also available molecular based (in vitro) testing, veterinary support (diagnostics, post mortem, animal care), and expertise in quality assurance and ISO/IEC compliance.

Research team members: Dr. Phil Byrne, Dr. Gilles Olivier. Submitted by DFO (ACRDP). For information contact Dr. Phil Byrne (byrne@dfo-mpo.gc.ca).

Understanding the opportunity and cost of organic aquaculture production

The goal of this project is to assess the costs and benefits of organic aquaculture for Canadian consumers, retailers, producers and the general public. The project will assess i) the Canadian and international demand for organic aquaculture products, ii) gaps between Canadian conventional aquaculture practices and prevailing organic product standards in Canadian and export markets, and iii) the basis for selected key organic aquaculture requirements for use in discussions of organic standards with stakeholders. It will further gauge stakeholders' willingness to utilize scientific evidence to assist in the evolution of organic aquaculture standards in Canada.

The project started in March 2005. It will lead to the development of draft standards for organic aquaculture production in Canada, as input for negotiations between stakeholders.

Research team: Keith Culver, Norman Siebrasse, Karen Finlay, David Castle. Submitted by AquaNet. For further information contact Keith Culver at the University of New Brunswick.
For information contact Keith Culver (Email: kculver@unb.ca).

Mar.'05-Jul'06

Evaluating site use in coastal areas

This project examines the problem of defining the value of marine areas based on characteristics of the marine site, as well as the cumulative ecosystems effects from alternative strategies for marine use, including the development of aquaculture sites. The research is directed at providing tools for supporting federal and provincial governments, as well as commercial, environmental and community groups regarding decisions on the effective use of marine sites. The procedure presents a problem-solving framework based on:

- a spatial analysis of the marine site's key ecosystem characteristics;
- a methodology for the evaluation of ecosystem effects from marine use;
- direct feedback from multiple decision makers participating in the marine governance process;
- the formulation of a multicriteria decision making problem for ranking aquaculture site evaluations; and
- an analysis of alternative marine site use and rankings by the various participants.

Tools have been developed including a spatial information interface that facilitates the estimation of cumulative effects by considering the impact of each site's overlapping ecosystem components. There is also a decision-support tool designed to reconcile the different and often conflicting perspectives associated with various marine use strategy alternatives.

Research team Dr. Dan Lane, Dr. Wojtek Michalowski, Dr. Rob Stephenson, Dr. Fred Page, Dr. Michael Sutherland, Dr. Yanlai Zhao, Mr. Ibrahim Ozer. Submitted by AquaNet. For information contact Dr Dan Lane (dlane@uOttawa.ca).
Website: http://aqua.management.uottawa.ca/

Jan.'05-ongoing

Blade kelp was cultured at the Maurice Lamontagne Institute near Mont Joli, Quebec.

Culture trials with brown algae in Chaleur Bay

There is growing interest in Quebec in the development of nutraceutical, cosmeceutical and horticultural fertilizer products based on marine algae. The production of algal biomass from culture has been suggested as a method of more effectively controlling the supply and quality of algae. Blade kelp (*Laminaria longicruris*) was cultured in a controlled environment at the Maurice Lamontagne Institute (MLI) in the fall of 2005 from spores obtained from fertile fronds harvested in Paspebiac Bay. In May 2006, the cultivated algae were transferred to the sea off Paspebiac.

The initial aim of the project was to monitor the seasonal growth of the algae until December 2006 and to compare cultivated and wild algae in terms of their respective components of commercial interest. Transfer to the sea was successful and the plants showed good growth until the middle of the summer. However, the algae were lost due to colonization by a bryozoan (*Membranipora membranacea*, invasive species) around late July, thus putting an end to the culture around late September. An analysis of the causes and consequences of this colonization will be added to the project. In addition, during the fall of 2006, the preculture experiment conducted in 2005 will be repeated, with seeding densities controlled to accelerate growth.

Apr.'06-Mar.'07

Research team: Louise Gendron, Gilles Savard. For information contact Louise Gendron (Email : gendronl@dfo-mpo.gc.ca).

Holistic health management in aquatic ecosystems

Our group comprises 7 investigators from 4 Universities in Atlantic Canada. The project establishes a geographically-rooted Strategic Knowledge Node, serving as a partnership between researchers and the aquaculture industry, to develop and advance the applied science(s) pertaining to healthy ecosystems, disease management, and the environmental footprint of Canadian aquaculture practices.

The core contention of this node is that optimal health management should aim at:

1) minimizing the impact of diseases in aquaculture systems and aquatic ecosystems, and
2) optimizing reciprocal influences between ecosystems and aquatic animal farming.

More specific objectives are to: Establish a strategic research community in the understanding and prediction of aquatic ecosystem health; Establish a multidisciplinary think-tank to initiate transdisciplinary synergies and provide guidance on new approaches to aquatic ecosystem health; Support innovative research initiatives promoting scientifically sound, environmentally responsible and ecologically sustainable aquaculture; Enhance research collaboration and networking in the area of ecosystem health, at regional, national, and international levels; Enable leveraging of additional funding to support fish health and ecosystem health research projects; Encourage effective transfer of knowledge to stakeholders with particular attention to private sector and highly qualified personnel.

Research team: Franck C.J. Berthe (UPEI), Omer Chouinard (U. Moncton), Larry Hammell (UPEI), Bruce G. Hatcher (U.C. Cape Breton), Michael Van Den Heuvel (UPEI), Karen Kidd (UNB), Matt Litvak (UNB), and David Speare (UPEI). For information contact Franck Berthe (Email: fberthe@upei.ca). Submitted by AquaNet. Jun.'06-Jul'07

An analysis of the challenges posed by applied research in aquaculture and the need to cross traditional discipline boundaries

Aquaculture research is a multi-disciplinary activity that involves, among other fields, natural, social sciences and political sciences and requires that investigators of diverse academic fields effectively communicate their expertise to answer questions of public interest. This project explores the challenges of conducting multi-disciplinary aquaculture research and the effective knowledge translation required to communicate among the various disciplines and the different aquaculture sector groups. The objective is to improve the co-ordination of aquaculture research in order to increase the integration of research results to effectively guide culture operations and community involvement.

The project has led to the development of a theoretical framework to analyse and understand the organisation and coordination of multidisciplinary aquaculture research. It resulted in a survey tool that generates consensus among various aquaculture stakeholder groups regarding the way questions are formulated and aquaculture issues are addressed.

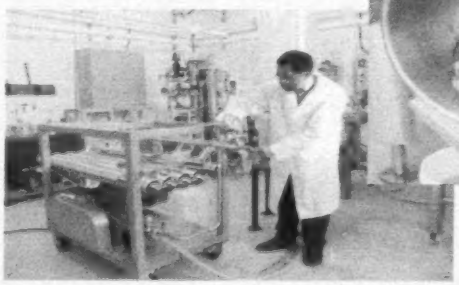
Research team: Jean-Paul Vanderlinden, Omer Chouinard, Brad Walters. Submitted by AquaNet. For information get in touch with Jean-Paul Vanderlinden, Université de Moncton, NB.
Apr.'03-Sept.'06

Aquaculture by-products the focus of research at Newfoundland's Marine Institute

Each year the aquaculture industry in Atlantic Canada produces significant quantities of processing discards. More stringent environmental regulations and increasing waste management costs are placing pressure on industry to identify alternative uses for waste streams. To assist industry in capitalizing on the tremendous potential for product development/diversification and value addition, the Fisheries and Marine Institute of Memorial University of Newfoundland opened the Atlantic Canada Fishery By-Products Research Centre in the fall of 2006. The centers' purpose is to use innovative research and development to encourage complete utilization of fish and shellfish, yielding significant benefits for the Atlantic Canadian region.

Proprietary R & D activities have been carried out at the facility dealing with various aquaculture processing discards. Finfish producers are looking to identify methods of preserving their processing discards for utilization as feed in the fur industry. And they are also looking at production of silage, as well as drying of the discards after oil extraction. Extrusion capabilities located within the facility allow researchers to produce various aquatic feed formulations that can be evaluated within the Marine Institutes' aquaculture facilities.

Research team: Thomas Brown. Submitted by AquaNet For information contact Tom Brown (Email: tom.brown@mi.mun.ca)



The Atlantic Canada Fishery By-Products Research Centre is developing new products and uses from fish and shellfish processing "waste".

Organizations Supporting Projects in this Publication

Alberta Aquaculture Research

Funding for aquaculture research in Alberta has traditionally come from agencies such as AAFRD (Alberta Agriculture, Food & Rural Development), the Alberta Aquaculture Association (often through in-kind contributions) and the Lethbridge Community College (mainly through the use of the facility structure). Frequently, these individual groups work together as a team under the umbrella of the Aquaculture Centre of Excellence (ACE - situated in Lethbridge). In Alberta there is also aquaculture money available through the Diversified Livestock Funds of Alberta (DLFOA). This funding consortium assists with agriculture research and development on a variety of other diversified livestock species. Since inception, the DLFOA has contributed over $250,000 cash to ten aquaculture projects. Value of these ten aquaculture projects totals nearly $900,000.

In 2006, aquaculture research involved five projects, including: "Aquaponics Development", Northern Crayfish Trapping / Marketing Potentials", Recirculating Aquaculture Biofiltration Remediation", "New Species Development for Warmwater Aquaculture", and "Plant Protein Alternatives for Aquaculture Feeds".

Partnership with our federal Government continues, through the Aquaculture Collaborative Research and Development Program. The ACRDP has approved assistance in the "Aquaponics Commercial Development" project at the provincial Crop Diversification Centre South, in Brooks Alberta. Federal - provincial cooperation in aquaculture is important for Alberta, and continues through recent industry workshops for strategic planning and direction. Report contributed by Eric Hutchings, AAFRD.

The British Columbia Aquaculture Research and Development Committee (BCARDC) – Aquaculture and Environment Fund

BCARDC was formed to enhance aquaculture research and development capacity and organization on the Pacific coast. Operating under the umbrella of the BC Innovation Council, BCARDC:

- Identifies and sets regional aquaculture R&D priorities;
- Provides strategic direction and advice regarding aquaculture-related R&D expenditures;
- Enables communication and improves coordination amongst entities involved in R&D and extension services related to aquaculture in British Columbia; and
- Provides reliable information on aquaculture, its activities and its sustainable management.

The BC Aquaculture Research & Development Committee encourages independent research to foster a fully sustainable aquaculture industry in British Columbia in conjunction with the stewardship of aquatic resources. The Committee exists to define research priorities, fund and coordinate research projects and communicate research results to the broader community. With industry representatives in the finfish and shellfish aquaculture sector as well as federal and provincial government agencies and university research institutions, the Committee has worked to significantly develop research capacity in British Columbia. The Aquaculture and Environment Fund was provided by the BC Ministry of Agriculture and Lands. For more information go to:
www.bcinnovationcouncil.com/initiatives/aquaculture.php

Quebec Department of Agriculture, Fisheries and Food (MAPAQ)

MAPAQ promotes the sustainable development and competitiveness of the fisheries and aquaculture sector in Quebec.
Its Innovation and Technologies Branch supports the scientific research and industry technical support programs carried out by its four R&D centres:

Centre maricole des Îles-de-la-Madeleine;

Centre aquaculture marin de Grande Rivière;

Station technologique piscicole des eaux douces, in Quebec City;

Centre technologique des produits aquatiques, in Gaspé.

These research centres generate knowledge useful to the industry and coordinate the technical assistance provided to aquaculture companies by a network of collaborators spread across Quebec.

MAPAQ is responsible for the development and implementation of strategies and programs intended to promote innovation. It provides financial support for technology watch, R&D, technology transfer and information dissemination projects, and encourages collaboration between industry, institutions and R&D organizations.

Mandated by the Quebec government, MAPAQ also allocates support from two research funds managed by the Société de développement de l'industrie maricole (SODIM) and the Société de recherche et de développement en aquaculture continentale inc. (SORDAC), and finances R&D organizations such as the Centre aquaculture du Côte-Nord, the Centre de transfert et de sélection des salmonidés and the Centre de recherche sur les biotechnologies marines. For more information go to:
www.mapaq.gouv.qc.ca/Fr/Peche/md/recherche/

National Research Council Institute for Marine Biosciences (NRC-IMB)

The National Research Council Institute for Marine Biosciences (NRC-IMB) in Halifax is one of the main anchors for life sciences research in Atlantic Canada. Its Industry Partnership Facility (IPF) and its coastal Marine Research Station enable companies to work side-by-side with researchers while gaining access to the institute's advanced research technologies. With a flexible and multidisciplinary approach, its life sciences research targets aquaculture, natural toxins and advanced research technologies, which include expertise in bioinformatics, functional genomics, metabolomics and proteomics.

Atlantic Canada Opportunities Agency (ACOA)

The Atlantic Canada Opportunities Agency (ACOA) was established in 1987 as the federal government's regional development agency for Atlantic Canada. ACOA has a broad mandate to increase employment opportunities and earned income in the Atlantic region.

The Agency has identified aquaculture as one of several strategic sectors for Atlantic Canada. In recent years, ACOA investments in aquaculture R&D have focussed on: salmon broodstock enhancements; cod and halibut aquaculture development; fish health; technology and services for the shellfish industry; developing extracts from marine plants; improving effluent treatments systems for land-based aquaculture; and integrated multi-trophic aquaculture.

Through the Atlantic Innovation Fund and the Business Development Program, ACOA has worked in partnership with industry stakeholders to make investments that build upon the industry's competitive advantages.

The Atlantic Innovation Fund was designed to increase the region's capacity to carry out leading-edge R&D that will lead to the launch of new products, processes and services.
(For additional information: http://www.acoa-apeca.gc.ca/e/financial/aif/index.shtml)

ACOA's Business Development Program was created to provide repayable financial assistance to small- and medium-sized enterprises to establish, expand or modernize operations.
(For additional information: http://www.acoa-apeca.gc.ca/e/financial/business.shtml)

AquaNet - Canada's Research Network in Aquaculture

Created in 1999 as a Network of Centres of Excellence to foster a sustainable aquaculture sector in Canada, AquaNet pursues a strategically focused research program that balances urgent, sector-relevant priorities with long-term research needs. It addresses various aspects of the sector including production, environmental and social concerns. Provided with seed money of $3.6 million annually as part of the federal government's innovation strategy, AquaNet has mobilised over one hundred researchers at universities across Canada and through international partnerships that connect excellent science with sector know how and investment.

AquaNet has focused its activities in several key areas:

- **Increased efficiencies and diversification:** Researchers are investigating the development and evaluation of new husbandry practices, including novel feeds, aimed at maintaining the well-being of cultured species while ensuring the production of a superior product. This is complemented by research to address disease and fish health priorities.
- **Environmental Integrity and Coastal Management:** Research into the development of integrated coastal management schemes that account for all users of the aquatic resource. AquaNet also utilizes international research partnerships to develop risk factor models related to wild – farmed interactions and the development of integrated aquaculture that combines seaweed, mussels and salmon for optimal results. Complementary research addresses social aspects affecting the sustainability of the aquaculture sector.
- **Fish Health and Welfare:** A recently established Aquatic Animal Health Research Advisory Team complements fish health programs and AquaNet's research into understanding the risks posed by fish diseases and developing mitigative strategies.

Underlying AquaNet's activities is the commitment to the development of innovative processes or products, an understanding and mitigation of any risk to the local environment and communities and utmost respect for the local and traditional knowledge.

AquaNet's vision is to help achieve a sustainable aquaculture sector, that is based on innovation and diversification, and the harmonisation and integration of the wild and capture fisheries into one sustainable aquaculture sector under a management framework that has widespread Canadian public support.

AquaNet's funding through the Network Centres of Excellence (NCE) program was discontinued in 2006. All AquaNet funded projects are to be completed by July 2007.

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Organizations Supporting Projects in this Publication

Pacific Salmon Forum

The BC Pacific Salmon Forum is an initiative of the Government of British Columbia, an independent citizen body using science and stakeholder dialogue to advance the sustainable governance of BC Pacific salmon. Appointed by the Premier Campbell, the Forum began operation in April 2005 and has been asked to develop recommendations to:

Protect and enhance the viability of wild salmon stocks and their economic, social and environmental benefits to British Columbians;

Increase public confidence in fisheries management generally, and aquaculture in particular, within the marine environment;

Enhance the economic, social and environmental sustainability of aquaculture for all coastal communities.

The Forum's goal is to generate balanced and impartial public policy recommendations by directing key research questions to appropriate government or academic institutions and engaging salmon industry stakeholders in an informed discourse about policy options. The Province allocated $5 million to fund the work of the Forum over a three-year period with over $4 million dollars allocated to outreach and research initiatives. Fo.. more information go to: www.pacificsalmonforum.ca/

The Réseau Aquaculture Québec

The Réseau Aquaculture Québec (RAQ) is a network of researchers (academic, provincial and federal government researchers, CEGEP professors) involved in aquaculture research in Québec. The network has been supported by Valorisation Recherche Québec (VRQ) and the Société de développement de l'industrie maricole (SODIM) from 2001 to 2006. From 2006 to 2012, the network will be supported through the "Réseaux stratégiques" program of the Fonds québécois de la recherche sur la nature et les technologies (FQRNT). RAQ's succeeded to bring together all Québec researchers with an interest in finfish and shellfish aquaculture, in both the fresh and marine environments, and to provide them with a forum for comparing and combining their research results and expertise.

RAQ has always had very close contact with the aquaculture industry in Québec, especially to its close association with SODIM and the Société de recherche et de développement en aquaculture continentale (SORDAC), partners who play an active role in the elaboration of the RAQ's scientific program.
For more information contact Céline Audet, Ph.D. Scientific Director, celine_audet@uqar.qc.ca or visit www.uqar.uquebec.ca/raq/.

Fisheries and Oceans Canada (DFO)

DFO's vision is excellence in service to Canadians to ensure the sustainable development and safe use of Canadian waters. DFO is responsible for developing and implementing policies and programs in support of Canada's scientific, ecological, social and economic interests in oceans and fresh waters. As a science based, sustainable development department, DFO's research is focused, in part, on monitoring the aquatic living resources and their environment, maintaining related databases, and providing environmental information for marine and freshwater related activities. The agency also maintains scientific capacity to deliver advice to assess risk for an ecosystem based approach to integrated management and develop resource management practices, regulations and standards. By transferring this knowledge to clients, public and media it fosters the protection, conservation and sustainable development of living aquatic resources and ecosystems.

The mission of Aquaculture Science is to conduct targeted and applied research, monitoring, science advice and technology transfer in research areas such as sustainable aquaculture, preventing and controlling aquatic animal diseases, environmental interactions, and applying genomics and biotechnology to aquatic ecosystems.

In addition to the department's aquaculture science programs, there is the Aquaculture Collaborative Research and Development Program (ACRDP). ACRDP is a DFO initiative to increase the level of collaborative research and development activity between the aquaculture industry and the department. ACRDP is an industry-driven program that teams industry with DFO researchers. The program allocates ACRDP funds to collaborative research projects that are proposed and jointly funded by aquaculture producer partners. ACRDP funding is approximately $4.5 million per year and is subdivided regionally. Since the program began in 2000, more than 180 research and development projects have been funded.

The key goals of the program are to:

- Improve the competitiveness of the Canadian aquaculture industry;
- Increase collaboration between the department and industry on scientific research and development;
- Facilitate the process of technology transfer and research commercialization through closer collaboration with the Canadian aquaculture industry; and
- Increase scientific capacity for research and development in the aquaculture sector.

Further information on priorities, plans, programs and projects can be found on the DFO web site: http://www.dfo-mpo.gc.ca.

SORDAC

SORDAC is a no profit corporation formed in 1993 by Quebec aquaculture sector stakeholders under Part III of the Companies Act (R.S.Q., c. C-38, s. 218). Its board of directors consists of 12 directors, 11 of whom are voting members—five from the private sector, four from the postsecondary education community, and two from the public sector and one non voting member from the public sector. Its 70 members, most of whom are active fish farmers, account for the bulk of Quebec's aquaculture production intended for consumption and stocking.

SORDAC's mandate is to:

- build consensus on action priorities;
- ensure the coordination and funding of research and technology transfer activities;
- foster the implementation of integrated R&D programs with institutional and industrial partners;
- promote effective networking between research and industry and partners;
- in order to increase the productivity and economic viability of Quebec freshwater aquaculture companies.

To fulfill its mandate, SORDAC pursues the following objectives:

- develop and implement a research and technology transfer strategy;
- develop and fund research activities that can be carried out by industry;
- organize and fund private-sector technology transfers;
- ensure concerted action among stakeholders and complementarity of R&D and technology transfer efforts;
- actively seek sources of funding for its activities.

To carry out its mandate, SORDAC received an initial allocation of funding of $600,000 from the Quebec Department of Agriculture, Fisheries and Food (MAPAQ) for fiscal years 1993-1994 and 1994-1995, a second allocation of $871,000 for fiscal years 1996-1997, 1997-1998 and 1998-1999, a third allocation of $300,000 for fiscal year 1999-2000, a fourth allocation of $900,000 for fiscal years 2000-2001, 2001-2002 and 2002-2003, a fifth allocation of $300,000 for fiscal year 2003-2004, and a sixth allocation of $1,200,000 for fiscal years 2004-2005, 2005-2006 and 2006-2007.

Natural Sciences and Engineering Research Council of Canada (NSERC)

NSERC's role is to make investments in people, discovery and innovation for the benefit of all Canadians. The organization invests in people by supporting more than 20,000 university students and postdoctoral fellows in their advanced studies. NSERC also promotes discovery by funding more than 10,000 university professors every year and it helps make innovation happen by encouraging more than 500 Canadian companies to invest in university research. For more information go to: www.nserc-crsng.gc.ca/

Genome British Columbia

Genome British Columbia was founded in July, 2000 as one of five centres supported by Genome Canada. It is a research organization that invests in and manages large-scale genomics and proteomics projects focused on areas of strategic importance such as human health, forestry, fisheries, ethics, agriculture and the environment.

By working collaboratively with all levels of government, universities and industry, Genome BC is the catalyst for a vibrant, genomics-driven life sciences cluster with far reaching social and economic benefits for British Columbia and Canada.

Currently Genome BC is managing 28 large scale projects with a total value of approximately $273 million. In addition to funding from Genome Canada, Genome British Columbia is supported by the provincial government and other investors.

Genome BC is currently supporting two projects with interest to the aquaculture industry. These are GRASP and eGRASP led by Drs. William Davidson (UVic) and Ben Koop (SFU).
For more information go to: www.genomebc.ca/

The National Research Council Institute for Ocean Technology (NRC-IOT)

The Institute for Ocean Technology (IOT) is Canada's national centre for ocean technology research and development. It is a branch of the National Research Council of Canada and it conducts research of benefit to Canadian marine industries. As part of its mandate IOT offers world-class expertise and facilities to address engineering challenges in the aquaculture industry. This includes improvements to containment and mooring systems, and improved understanding of the how wind, waves, current and sea ice interact with man-made structures.

Using numerical, model and full-scale studies, the Institute can predict or evaluate the performance of engineered systems in the ocean environment. Its indoor research facilities include a 75-metre by 32-metre Offshore Engineering Basin, a 200-metre Towing Tank, and the world's longest Ice Tank at 90 metres. For information on how the Institute can assist your aquaculture operation, please contact Dr. Bruce Colbourne at B.Colbourne@nrc.ca.

In 2003 the Institute officially opened its Ocean Technology Enterprise Centre, a facility to assist the growth and development of new ventures in ocean technology. With a Young Entrepreneurs Program and a Co-Location Program for new enterprises, the center helps companies and individuals develop their concepts and technologies in a supportive environment. For additional information contact Noel Murphy at noel.murphy@nrc.ca or go to *iot-ito.nrc-cnrc.gc.ca/*.

Organizations Supporting Projects in this Publication

Canadian Centre for Fisheries Innovation

The Canadian Centre for Fisheries Innovation (CCFI) is in the business of solving problems and creating opportunities for the aquaculture industry and fishery through science and technology. Since its opening in 1989, over 200 leading Canadian companies in the aquaculture, processing, harvesting, biotechnology and related sectors have come to CCFI for help developing new products, new technologies and techniques, and solving virtually every type of technical problem that the industry faces.

What makes CCFI stand apart is the unique working relationships it has established with fourteen universities and colleges in Atlantic Canada. With these arrangements, the hundreds of scientists, engineers and technologists in those institutions provide their expertise and facilities to CCFI clients. Many are world leaders in their fields, and have made it possible for the Centre to carry out 670 industrial projects worth $80 million over 17 years.

The Centre offers its clients a comprehensive service. Industrial Liaison Officers analyze the client's problem or opportunity, draft a research plan and budget, identify and secure the services of scientific or engineering specialists to carry out the work, and if needed, enlist other organizations in getting involved. The Centre also helps fund the initiative.

CCFI shepherds the client company through the maze of activities in the research, so that it can continue to concentrate on its business needs. In aquaculture the Centre's scientific and technological services run the entire gamut from early feeding trials for new developing species to offshore cage development. For more information go to *www.ccfi.ca* or call our offices: in Halifax, 902 835 4210 and in St. John's, 709 778 0517

Société de développement de l'industrie maricole inc. (SODIM)

Société de développement de l'industrie maricole (SODIM) inc. was founded in 1997 for the purpose of providing firms interested in marine aquaculture with flexible financial assistance tailored to their needs. SODIM is a not-for-profit corporation and its mission is to contribute to the creation and development of profitable, competitive marine aquaculture enterprises.

To achieve its mission, SODIM has set the following goals:
1) To promote the development of a viable marine aquaculture industry within its territory, namely in the Gaspé Peninsula, Magdalen Islands, Lower St. Lawrence and North Shore, specifically by:

- Providing financial assistance for the start-up, diversification and expansion of marine aquaculture enterprises.
- Offering technical assistance and advisory services to marine aquaculture enterprises.
- Promoting research and development and technology transfer in aquaculture;

SODIM has two important tools with which to achieve its mission – an investment fund and a R&D fund. The general purpose of the R&D fund is to stimulate research and technology transfer and promote the development of freshwater and marine aquaculture enterprises in the maritime regions of Quebec. The fund is designed to support pre-competitive research activities, i.e., activities of a very practical nature. With the fund, SODIM seeks to promote innovation in the aquaculture industry in these regions. With the collaboration of its partners, SODIM is responsible for identifying research priorities and developing and overseeing the implementation of a science action plan.
For more information go to: *www.sodim.org/*

Genome Atlantic

Genome Atlantic is a non-profit group, dedicated to promoting and fostering genomics research in the four Atlantic provinces. One of six regional genomic research centres in Canada, Genome Atlantic invests in large-scale genome research projects and platforms. It is dedicated to developing leadership in carefully selected areas of genomics and proteomics, and to build genomics investment and economic growth in Atlantic Canada.

In order to accomplish these objectives, Genome Atlantic brings together industry, governments, universities, hospitals, research institutes and the public in support of regional genomics research and its ultimate exploitation to help develop the knowledge-based economy in Atlantic Canada.

Research Programs within Genome Atlantic focus on local strengths, including health, agriculture, forestry and environment sectors. Programs include Atlantic Cod Genomics and Broodstock Development, Enhancing Commercial Culture of Atlantic Halibut and Senegal Sole, and the Atlantic Medical Genetic and Genomics Initiative (AMGGI).
For more information go to:
www.genomeatlantic.ca

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